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THE

MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

Mineralogical Society

GREAT BRITAIN & IRELAND

INSTITUTED 3rd FEBRUARY, 1876.

EDITED BY A COMMITTEE OF COUNCIL.

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1882.

PROCEEDINGS

OF THE

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND.

1881.

EXCERPT MINUTES OF COUNCIL MEETING

Held at the Albert Rooms, Stonygate, York, Sept. 2nd, 1881.

Prof. M. F. Heddle, F.R.S.E., President, in the Chair.

The following gentlemen were duly elected Members of the Society.—

James Brebner, Esq., M.A., Dundee.

J. A. Harvie Brown, Esq., Dunipace, Scotland.

R. F. Mallet, Esq., Geol. Survey, India.

Mons. F. Micault, St. Brienc, France.

The following resolution was adopted.

"That the authors of all papers which are printed in the Magazine shall in future defray one third of the cost of all such coloured illustrations of their papers as have been approved by the Editing Committee, but that there shall be nothing in this resolution to prevent an author from withdrawing such illustrations, if he considers the estimate to be excessive; nor shall there be any thing which shall prevent the Editing Committee on the one hand, or the author on the other, from undertaking the whole cost of such illustrations in the event of there being any difficulty, or difference of opinion, as to the estimate; it being always understood that the question of admission of all such illustrations is to be determined by the Editing Committee, subject, of course, to the ultimate decision of the Council."

THE SIXTH ANNUAL GENERAL MEETING OF THE SOCIETY

Was held on the 2nd of September, 1881, at 4 p.m., at the Albert Rooms, Stonygate, York.

PROF. M. F. HEDDLE, F.R.S.E., President, in the Chair.

The Minutes of the last two Meetings of Feb. 15th and March 30th were read and confirmed.

The Auditor's certificate of the scrutiny of the balloting papers for Council and Officers was read, and the following were declared duly elected for the ensuing year,

President—W. H. HUDLESTON, M.A., J.P., F.G.S.,

Council—T. DAVIS, F.G.S.,
JAS. GEIKIE, F.R.S.,
M. HAWKINS JOHNSON, F.G.S.,
H. LOUIS, ESQ.
REV. W. W. PEYTON,

in place of Messrs. Collins, Flight, Greene, Hudleston and Scott.

General Secretary—R. H. SCOTT, F.R.S.

On the motion of Mr. Greg, seconded by Mr. Sorby, the warmest thanks of the Society were unanimously tendered to Dr. Heddle for his services as President during the last two years.

The following Report of the Council for the past year was read and adopted.

"The Society has now completed the fifth year of its existence, and its numbers show a slight improvement, though their total remains, as in the last two years, at 172.

"The number of ordinary members has been increased by two, while that of the Associates has been diminished by an equal amount.

"The precise figures at present are:

Corresponding Members	24
Ordinary Members .	126
Associates	22
Total	172

"The balance sheet, which appeared with Part 20 of this Magazine exhibits a balance in the Treasurer's hands of £42 4s. 3d., but the statement of assets and liabilities shows that since the date of the last balance sheet the expenditure on printing has been larger than was justified by the

condition of the Society's finances. The debt to our printers, outstanding on Dec. 31st, 1880, has been increased by more than £100 during the year, standing at £230 16s. 6d., instead of £129 10s. 3d. as in the accounts for 1879.

"It is true that the sale of the Magazine has produced £40 6s. during the year 1880, whereas only £15 8s. was realised from the same source in 1879. The Council may, therefore, assure the members that they have put down the value of the stock in hand of the Magazine at a very low estimate (one third of its selling price) when they have entered £185 for this item as a set off against the printer's account.

"They have, however, deemed it advisable to restrict, temporarily, the issue of the successive parts of the Magazine, and, accordingly, only three instead of four parts have appeared since the last Annual Meeting; viz., No. 18 in Sep. 1880, No. 19 in April, and No. 20 in August 1881.

"They determined in December last that the price of the yearly series of the Magazine shall be at least equal to the amount of the yearly subscription of the Members.

"By a continuance of judicious economy in the department of printing, the Council feel confident that they will be able to replace the Society in a satisfactory financial position, as a considerable sum has been paid to the printers during 1881, and the amount due to them, after the issue of Part 20, is only £153 12s. 1d., while the cash in hand is £74 15s. 9d., and the outstanding bills, exclusive of printing the Magazine, do not exceed £6.

"The chief contributor to the Magazine has been our President, whose paper on "The Geognosy and Mineralogy of Sutherland," in continuation of its predecessors on Shetland, Orkney, and Caithness, occupies the greater part of two of the numbers which have appeared during the year.

"As soon as this paper is completed, a geological map of the county will be issued, which has been drawn by Prof. Heddle upon a map prepared from original survey and engraved for the Duke of Sutherland, K.G. The Council are in a position to say that this map, which will be sold to non-members at the price of a guinea, will be distributed to the actual Members and Associates at the time of its appearance *gratis*, as a part of the Magazine.

"The only other paper calling for special notice has been a further contribution from Mr. Collins "On Cornish Tinstones and Tin Capels," which appeared in Part 18.

"In conclusion, the Council have to report that the Society has sustained a severe loss in the resignation by Mr. J. H. Collins of the combined offices of General Secretary and Editor of the Magazine, which he has filled with such advantage to the Society ever since it was first founded in 1876.

"It was mainly by Mr. Collins' efforts that the Society was brought into being, and it is to his untiring energy that its present position is almost exclusively due. His resignation became inevitable owing to his acceptance of a post connected with the Rio Tinto Mines in Spain, which necessitated his residence out of England. The Council have as a temporary measure requested Mr. R. H. Scott to act as General Secretary for the present, and have entrusted the editorial functions to a committee of five Members, iucluding the President and General Secretary."

(Signed) M. F. Heddle, President.

The President then called on Mr. Greg to move his proposed change in Rule 17, of which notice had been duly given.

Mr. Greg proposed and Mr. Sorby seconded the following alteration of Rule 17.

"At meetings of the Council three shall be a quorum, of whom one shall be either the President, one of the Vice-Presidents, or the General Secretary."

The alteration was put to the vote and carried unanimously.

The President proposed, and Mr. Dudgeon seconded the following addition to Rule 24.

"All expenses incurred at local meetings are to be defrayed by the Members who take part therein."

This addition was also carried unanimously.

Mr. Scott proposed, and Mr. Walker seconded the following addition to Rule 31.

"The name of any Member or Associate whose subscription is more than three years in arrear shall, after intimation to said Member, be erased from the list of the Society, but the person expelled shall have a right of appeal, as provided by Rule 28."

This addition was also carried unanimously.

The General Secretary then read a paper by Prof. A. Liversidge "On a peculiar copper ore from Coombing Copper Mine, New South Wales."

The President and other Members expressed their agreement with the Author of the paper that the substance was not a specific ore but only a mixture, and Dr. Trechmann pointed out that if so much silica was present as had been found the mineral should be translucent in thin slices.

Mr. P. Dudgeon read a paper "On the occurrence of 'Linarite' in Slag."

Mr. Sorby pointed out the very great interest which attached to the discovery of minerals formed under conditions of which we knew something, such as those found in furnace products.

Mr. I'Anson read a joint paper by himself and Mr. E. A. Pankhurst "On Artificial forms of Silica," illustrated by a series of preparations.

The President stated that he considered the paper to be one of the most interesting he had heard for a long time. He himself had studied Agates for many years, and he possessed a collection of over 5000 specimens. His friend, Mr. Dudgeon, had also a very large collection.

The paper gave rise to considerable discussion, and Dr. W. Lant Carpenter stated that he had produced a deposit of Silica of considerable hardness by precipitation from an Alkaline Silicate.

Dr. Trechmann read a preliminary "Note on a new occurrence of Epistilbite."

The General Secretary read a note by Mr. W. Terrill "On Artificial Crystals of Specular Iron, found in a Copper works Slag."

EXCERPT MINUTES OF COUNCIL MEETING,

Held at 116, *Victoria Street, Dec.* 14*th*, 1881.

W. H. Hudleston, Esq., F.G.S., President, in the Chair.

The following gentlemen were duly elected Members.

H. Baker, Esq., F.C.S., Manchester,

R. Fleming, Esq., 1, Exchange Place, Dundee.

Resolved—"That the Geological Map of Sutherlandshire, prepared by Professor Heddle, be issued as part 21 of the Magazine."

A GENERAL MEETING OF THE SOCIETY

Was held on Wednesday, December 14*th*, 1881, *at* 116, *Victoria Street, at* 8 *p.m.*

W. H. Hudleston, F.G.S., President, in the Chair. 9 Members were present.

The minutes of the Annual General Meeting at York, Sept. 2nd, were read and confirmed.

The Secretary read the following paper "On some minerals from the Sodalite Syenite of Julianshaab District, South Greenland," by Johann Lorenzen, Communicated by Prof. Johnstrup (Foreign Member).

The President announced that two visitors were present from the Kimberley Mine, South Africa, Messrs. E. Baring Gould and Porter Rhodes, and he invited them to give an account of the working of the mine.

Mr. Porter Rhodes exhibited a model of his Great Diamond, weight 152 carats, and several specimens of diamonds, as well as of the "reef," the diamantiferous matrix, with crystals imbedded in it.

Mr. Baring Gould exhibited photographs of the workings of the mine.

An interesting conversation ensued, and the President in closing the meeting expressed the warm thanks of the Society to their visitors of the evening, for the very interesting communication they had made.

Mr. Rudler exhibited a specimen of native copper from the sinter of a geyser in Iceland.

EXCERPT MINUTES OF COUNCIL MEETING.

Held at 166, *Victoria Street, March* 23*rd*, 1882.

W. H. Hudleston, F.G.S., President, in the Chair.

The audited Balance Sheet for the past year was submitted, and ordered to be printed for distribution to the Members.

The following gentlemen were duly elected Members.

Alexander Davidson, Esq., Fergus Place, Kirkcaldy, Fifeshire.
Ridley Henderson, Esq., 9, Bush Lane, Cannon Street, E.C.
Alexander Hutton, Esq., Royal Bank, Arbroath.
Colin Livingston, Esq., Fort William, N.B.
George Tate, Ph. D., F.G.S., College of Chemistry, Liverpool.

ASSOCIATE:

H. F. Collins, Esq., Royal School of Mines.

Abstract of Receipts and Payments of the Mineralogical Society, for the Year 1881.

RECEIPTS.

Dr.

	£	s.	d.
Balance on January 1st, 1881	42	4	3
Subscriptions for 1882	5	10	0
——— ——— 1881	90	18	0
——— ——— previous years	31	15	0
Life Compositions (7)	73	10	0
Entrance Fees	17	17	0
Sale of Publications (exclusive of Publisher's Sale)	12	19	2
Dividends and other small items	3	6	11
	£278	0	4

PAYMENTS.

Cr.

	£	s.	d.
Printing and Illustrations	199	12	6
Expenses incidental to Meetings	0	7	6
Clerical Expenses	6	17	6
Postage and Parcels	10	13	9
Investments	51	11	11
Sundry small items	3	8	6
Balance in hand and at Bank	5	8	8
	£278	0	4

March 6th, 1882.

Examined and found correct.

BENEDICT KITTO.
F. W. RUDLER.

LIABILITIES.

	£	s.	d.
Lake & Lake, Printing	121	1	3
Wightman & Co., Printing	1	19	0
Heard & Son, Printing	0	13	0
Subscriptions paid in advance	5	10	0
Excess of Assets over Liabilities	111	14	4
	£240	17	7

ASSETS.

	£	s.	d.
Subscriptions for 1881, unpaid	22	15	0
——— prior to 1881, ———	12	12	0
New Three per Cent. Annuities, at Par	136	12	3
Stock of Publications, valued at average Annual Sale	36	19	0
Publications sold by Publishers (amount unpaid)	26	10	8
Cash at Bank	0	17	4
Petty Cash in hand	4	11	4
	£240	17	7

Signed { BENEDICT KITTO.
F. W. RUDLER.

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No. 23. NOVEMBER, 1882. Vol. V.

*On some Minerals from the Sodalite-Syenite in Juliane-haab district, south Greenland.**

By Joh. Lorenzen.

Communicated by Prof. Johnstrup.

Read December 14th, 1881.

IT is well known to mineralogists, that *Giesecke*, who in the years 1806—13 travelled in Greenland, brought home from Julianehaab district some new minerals, which he handed over to the Copenhagen Museums. In 1853-4 *Dr. Rink* supplied the museum of the Copenhagen University with a large collection of the same minerals, mostly in large and fine specimens, and the same collections have lately received a most valuable and considerable addition, through the travels of *Mr. K. J. V. Steenstrup* of the Danish Geological Survey of Greenland. Some of these interesting minerals, occurring in the Syenite on both sides of the fjords Tunugdliarfik and Kangerdluarsuk, have already long been known, whereas others had either been not found there before or at least not analysed or described.

As better materials for the examination of the minerals than those which were at the disposal of former investigators are now available, I have at the suggestion of Professor Johnstrup, undertaken the following examination.

The chief constituents of the Sodalite-syenite, the name of which is due to *Mr. Steenstrup*, are a greenish-white *felspar*, *arfvedsonite* (and

* Translated from Meddelelser fra Grönland, 2det Hefte, Kjoebenhavn, 1881, where a French resumé is given.

ægirine) together with *sodalite*†. In some places the minerals assume very considerable dimensions, especially the arfvedsonite. The chief accessory is *eudialyte*, the garnet-like colour of which, when occurring in larger quantity, gives to the rock a reddish-brown tinge; more scarcely are found crystallized *nepheline* and two new minerals mentioned below. There likewise occurs, at single spot, crystallized *lievrite*, together with calcareous spar, and finally some zeolites, in particular analcime and natrolite. A circumstance which gives this rock a peculiar interest is, that most of the minerals above mentioned are found connected in a very similar way in the south of Norway, viz: in the syenite of the Langesunds fjord, where also occur arfvedsonite, ægirine, sodalite, nepheline (elæolite), eudialyte (eukolite), analcime and natrolite (brevicite).

I have examined most of the constituents of the sodalite-syenite, and perhaps it will not be out of place briefly to mention some former investigations. Firstly we find published a series of analyses of the *arfvedsonite* from Kangerdluarsuk, and no analysis of the *ægirine* from the same locality, but in the following it will be shown that the materials analysed in all cases have been either ægirine, or a mixture of arfvedsonite and ægirine The *eudialyte* is the best known of these minerals, but I have found that it contains a small quantity of cerium not indicated in the former analyses, which perhaps may be of some interest, an equal quantity having been found in the corresponding Norwegian mineral *eukolite*. As to the *sodalite*, the former analyses show clearly that the substance cannot have been fresh.

I shall now detail the several investigations.

I. Felspar.

The felspar occurs in greenish-white masses, often of perfect cleavage. In thin plates it is almost transparent. Under the microscope it has proved to be a microcline. The composition is:—

SiO_2	..	..	62·74
Al_2O_3	..	..	19·60
Na_2O	..	..	3·56
K_2O	..	..	13·09
			98·99

II.—Arfvedsonite.

Literature: Annnals of Phil., 1823 (Brooke). — Berz. Jahresber. 1825, 149 (Arfvedson).—Annales des mines 1832, T., I., 192 (Thomson)—Journ. f. pr. Ch. 13, 3, and 91, 449 (Kobell).—Pogg. Ann. 105, 292 and

† For further communications, maps, etc., see the paper of *Mr. Steenstrup*, in Meddelelser fra Grönland, etc.

06 (Rammelsberg).--Zeitsch. f. Kryst. u. Min., IV. 94 (Doelter).—Berg— . Hüttenmann. Zeitung 1865-66, (separately printed as: *mineralogische tudien* v. Aug. Breithaupt).

The arfvedsonite, the first name of which was "ferriferous hornblende," as distinguished by *Brooke* in 1823 as a peculiar mineral species. He d not examine the chemical composition, which indeed has not since en fully understood. The angle of cleavage he found to be 123° 55 · *'itscherlich* likewise showed it to be the same as that of hornblende, id finally an analysis by *Arfvedson* seemed to show a conformity in it[8] iemical composition.

Later on, the cleavage was examined by *Breithaupt*, and the chemical mposition by *Thomson*, but although his analysis differs considerably om Arfvedson's, he has not observed the most characteristic peculiarity, ıding no soda, but instead of this 8 per cent. manganous oxide.

That these analyses cannot have been made on veritable arfvedsonite, d so must be set aside, is now most evident, newer ones having en made by *Kobell* (I.), *Rammelsberg* (II.), and *Doelter* (III), as llows.

	I.	II.	III.
Cl. ..	0·24	—	—
SiO_2 ..	49·27	51·22	52·22
Al_2O_3 ..	2·00	trace	0·64
Fe_2O_3 ..	14·58	23·75	28·15
FeO ..	23·00	7·80	5·35
MnO ..	0·62	1·12	0·54
CaO ..	1·50	2·08	2·19
MgO ..	0·42	0·90	1·45
Na_2O ..	8·00	10·58	10·11
K_2O ..	—	0·68	0·34
Loss by heat	—	0·16	—
	99·63	98·29	100·99

It will be seen that the analysis of Kobell differs considerably from de others, between which the difference is not greater than will be en found in analyses of minerals, of which material of absolute purity ı not be secured.

Already in 1866 *Breithaupt*, by mere crystallographic investigation, de the observation that several minerals in collections are called vedsonite incorrectly, and with respect to this he says: "von en scheint in die Sammungen am häufigsten ein Pyroxen, nämlich · Aigirin, als Arfvedsonit zu existiren ‡." This remark however has d had any influence on the position of *arfvedsonite* in the system.

‡ l. c., page 50.

The arfvedsonite occurs at Siorarsuit and Kangerdluarsuk, partly massive, partly crystallized. The crystals, which have not before been described, are seldom found, but sometimes they attain a considerable development. The biggest crystal in the museum of the University is c. 9 inches long and c. 3½ inches in diameter; the terminating planes however are missing in this crystal; this often is the case on account of the growing together of the arfvedsonite with other minerals in the sodalite-syenite. The colour of fresh crystals is dark, but often they are grey, owing to an alteration on the surface; still a fracture shows the dark colour. The surfaces most frequently are dull, so that reliable measurements cannot be made. The prismatic and pinacoid planes are the best reflecting, whereas I could not measure the angle between a terminal plane and a pinacoid by the reflecting goniometer on more than one crystal. The rest of the angles are measured by the hand goniometer, but the planes being often very small, the measurements cannot be very precise. The result of the examination is that many of the characteristic forms of the amphibole are found to occur in the arfvedsonite.

Most commonly combinations of ∞P and $\infty \breve{P} \infty$. P and $2 \breve{P} \infty$ are found. I have further found oP on a single crystal. Twins occur with the orthodome as composition-face.

The following angles were obtained by the reflecting goniometer:—

$$\infty P = 123°37' - 124°48'$$
$$2 \breve{P} \infty : \infty \breve{P} \infty = 119°48'$$
$$\infty P : \infty \breve{P} \infty = 117°38'$$

From the two last is calculated.

$$2 \breve{P} \infty : 2 \breve{P} \infty = 120°24'$$
$$\infty P = 124°44'$$

The most exact measurement, however, may be made on the cleavage faces, which frequently are excellently reflecting. On such the angle was found to be 124°22′.

By the hand-goniometer we obtain:—

$$P : P = \text{c. } 148° \qquad P : 2 \breve{P} \infty = \text{c. } 150°$$

One thing is especially worth remarking:—the crystals are *never striated.*

The massive arfvedsonite is either dark and breaks easily,—the cleavage faces then are both distinct and reflecting—or it is somewhat greyish. In the last case the cleavage-faces become more dull, the coherence more solid, and the mineral penetrated with small fissures, which are filled with a whitish mineral. The substance used for the analysis was taken from the first variety, large massive specimens of which are preserved in the

auseum; besides it is also found adherent to ægirine, eudialyte and odalite.

Cleavage-faces: the prismatic and pinacoid planes; the last being more istinct than the corresponding ones of amphibole.

The fracture sometimes is conchoidal, often vitreous in lustre.

Streak and powder *dark-blue grey*, a very important distinction etween it and ægirine.

Hardness between that of felspar and that of apatite. Specific gravity ·44 (*Brooke* also found 3·44).

Fuses easily and forms vesicles in a Bunsen's gas lamp without the se of the blowpipe. Yields a dark magnetic bead.

For the chemical analysis the above mentioned dark massive arfvedsonite as used, which, when carefully selected, might be obtained very pure, nd the analysis was effected in the usual manner. The iron oxide nd sesquioxide were separated according to the method indicated by *oelter*, (Fres. Zeits. f. analyt. Chemie 18 Jahrg. P. 50), viz: the ineral is decomposed by a mixture of hydrofluoric and sulphuric acids, . an atmosphere of carbonic acid, and the solution titrated with rmanganate of potash. Three titrations gave accordant results.

SiO_2	43·85	0·731		0·731
Al_2O_3	4·45	0·044		
Fe_2O_3	3·80	0·024	..	0·068
FeO	33·43	0·464		
MnO	0·45	0·006		
CaO	4·65	0·083		
MgO	0·81	0·020	..	0·716
Na_2O	8·15	0·132		
K_2O	1·06	0·011		
Loss by heat	0·15			
	100·80			

From the analysis is then obtained:—

R : R : Si = 0·716 : 0·068 : 0·731
= 10·53 : 1 : 10·75
= 11 : 1 : 11

hich affords the formula:—

$$11\ R\ SiO_3 + R_2O_3.$$

Further:—

Fe (Mn) : Ca (Mg) : $Na_2(K_2)$ = 0·470 : 0·103 : 0·143
= 14 : 3 : 4

hich approximatively affords:—

$$\left.\begin{matrix} 4\ Na_2\ SiO_3 \\ 3\ R\ SiO_3 \\ 14\ R_1\ SiO_3 \end{matrix}\right\} + 2R_2O$$

where $Fe_2 : Al_2 = 1 : 1{\cdot}8$. The above formula gives the following composition:—

$21SiO_2$	1260	SiO_2	43·04
$\frac{4}{3}Al_2O_3$	137·33	Al_2O_3	4·68
$\frac{2}{3}Fe_2O_3$	106·66	Fe_2O_3	3·64
$14FeO$	1008	FeO	34·43
$3CaO$	168	CaO	5·74
$4\,Na_2O$	248	Na_2O	8·47
	2927·99		100·00

It will be seen that neither my analysis nor the formula agrees wit the former ones. I was surprised to find almost the whole quantit of iron present as protoxide, but the smaller quantity of silica and th rather considerable amount of alumina are also remarkable. To explain th difference it may not be out of place to state and consider what former in vestigators say about the substances used for their analyses.

Kobell had obtained a specimen from one of Giesecke's collections, which the arfvedsonite was adherent to eudialyte. The description its appearance accords with that of the arfvedsonite; unfortunat he does not mention, whether he has used a crystal or a massive spe men, nor does he give the specific gravity. Still he is surprised (Jou f. pr. Ch. 91, 450,) by the difference between his analysis and that

Rammelsberg, who does not state the angle of cleavage obtained his own measurements. The specific gravity he states to be 3·589, wh is somewhat more than that of the arfvedsonite; further he says: "d Arfvedsonit, welchen ich zur Analyse benutzte, bildete *stark gestreifte, Ende zerbrochene Prismen*," (it will be remembered the arfvedsonite nev occurs as such; but the description strikingly agrees with ægirine) and continues; "und war mit Eudialyt und Sodalith stark verwachsen."

Doelter says, that the angle of cleavage places the mineral in t amphibole-group, but then he adds: "an den mir vorliegenden Stück von Arfvedsonit, der mit Eudialyt vergesellschaftet war, fand ich n Krystallen ohne Endflächen, die die Combination des Prismas mit ein Längsfläche zeigten. *Die starke vertikale Riefung gestattete keine Messu mit dem Reflexions-goniometer.*"

The museum of the university now possesses a great many specimen with which the descriptions of *Doelter* and *Rammelsberg* agree very we if one single alteration be made; viz: *to put the name of ægirine in place of arfvedsonite.* That the angle of cleavage nevertheless is found Doelter to be the same as that of amphibole, is easily explained by t circumstance, that arvedsonite and ægirine often are very closely grow together and as the cleavages are more distinct in arfvedsonite than

ægirine, these have been determined by the first, although it may perhaps have been in small quantity.

The arfvedsonite has hitherto held an isolated place in the system, but can now be referred to the general formula of aluminiferous amphibole, which *Rammelsberg* has adopted in the last edition of his Mineralchemie, viz:

$$\left\{\begin{matrix} m\,R\,SiO_3 \\ n\,R\,O_3 \end{matrix}\right\}$$

III. Ainigmatite.

Several crystals of this mineral, which firstly was determined by *Breithaupt** are preserved in our museum, and have been found at Naujakasik. Their form is monoclinic, and at the first look they seem to resemble the arfvedsonite. The general combination is ∞P, $\infty \breve{P} \infty$, $\infty \bar{P} \infty$, together with a pyramid and two sets of planes, which, as the base is absent, cannot be rigorously determined. Perhaps they are clinodomes. The orthopinacoid plane is very characteristic, this plane not being developed on arfvedsonite. Further, the two minerals differ considerably in other respects, which will be evident from the following properties of the ainigmatite.

Prismatic angle (measured with hand-goniometer) = 114°.

Streak reddish-brown.

Specific gravity of a perfect, small, tolerably pure crystal was found = 3.80.

Still the two minerals resemble each other, as both are dark coloured and have the hardness = 5.5. If the streak is not tried or the prismatic angle not measured, one is easily mistaken. An analysis of the ainigmatite was not undertaken, as the few crystals in the museum do not seem to be pure enough to give a satisfactory result.

Together with the ainigmatite *Breithaupt* has mentioned an isomorph mineral, *Koelbingite*, which differs from the first by a green streak and a smaller specific gravity; he supposes the ainigmatite to be pseudomorphous from the koelbingite. To which I shall merely remark, that our museum does not possess any koelbingite, but several crystals of ainigmatite, which being all very fresh and unaltered, can scarcely be admitted to be pseudomorphous.

IV. Ægirine.

Literature, Pogg. Ann. 61, 543 (Scheerer). 80, 314 (Plattner & Breithaupt) 103, 286 and 302 (Rammelsberg), 122, 118 (Rube & Kutzkow). Comptes Rendus 56, 846 (Pisani).—Zeits. f. Kryst. Min. IV, 91 (Doelter).

* l.c. P. 51.

Ægirine till now has been known chiefly as an augitic mineral from Brevig, showing a remarkable resemblance in chemical composition to arfvedsonite. That this, with respect to the last, was not correct, has already been stated above.

The specific gravity of the Norwegian ægirine is stated by *Breithaupt* to be 3.432—3.504; by *Rammelsberg* 3.578 and the prismatic angle 86°52′. I give here the analyses of *Rammelsberg* (I), *Pisani* (II), Rube (III).

	I.	II.	III.
TiO_2 ..	— ..	— ..	1.06
SiO_2 ..	50.25 ..	52.11 ..	50.03
Al_2O_3 ..	1.22 ..	2.47 ..	0.55
Fe_2O_3 ..	22.07 ..	22.80 ..	28.68
FeO ..	8.80 ..	8.40 ..	1.98
MnO ..	1.40 ..	— ..	1.52
CaO ..	5.47 ..	2.60 ..	1.42
MgO ..	1.28 ..	0.41 ..	1.33
Na_2O ..	9.29 ..	12.10 ..	12.20
K_2O ..	0.94 ..	— ..	—
Loss by heat	— ..	0.30 ..	1.05
	100.72	101.19	99.82

Ægirine is found at Kangerdluarsuk, Siorarsuit and Kumernit, grown together with eudialyte, sodalite and arfvedsonite. Often the arfvedsonite is coated with crystallized ægirine, which may very easily mislead in the determination of the minerals, the streak however immediately shows the difference. The mineral generally occurs in distinct, broken crystals, much striated along the axis, nearly always unaltered and with a certain metallic lustre. Some few non-striated crystals are also found, such as may be measured by the reflecting goniometer. On some crystals I found besides the fundamental pyramid, a very acute pyramid, and two clinodomes, the angles of which I was not able to measure by the hand-goniometer on account of the smallness of their planes. The general combination is ∞P. ∞P∞. ∞P∞. P. By the reflecting goniometer ∞P = 86°58′—87°6′ and P : ∞P = 120°51′ were found. By the hand-goniometer the angle between the polar edge of the pyramid and ∞P∞ was found to be c.105°. These angles agree with those of augite.

The cleavage is prismatic, not so well developed as in the arfvedsonite, still it is easily observed when a polished face of the mineral is turned in the sunlight.

Streak and powder, light green.

Hardness, 5.5—6. Specific gravity, 3.63.

Fuses easily before the blowpipe to a dark magnetic bead. Is not decomposed by acids.

For the chemical analysis a fresh crystal was used, which under the microscope had proved to be very pure. The oxides of iron were determined as with arfvedsonite. The analysis yielded the following results:

		Quotients.	
SiO_2	49.04	0.818	0.818
Al_2O_3	1.80	0.017	0.201
Fe_2O_3	29.54	0.184	
FeO	4.82	0.067	
MnO	trace	—	0.115
CaO	2.70	0.048	
MgO	trace	—	
Na_2O	13.31	0.215	0.215
K_2O	trace	—	
	101.21		

$Na_2 : R = 0.215 : 0.115 = 2 : 1$ $\quad$ $R : R = 0.201 : 0.115 = 1.75 : 1 = 2 : 1$

$R : Si = 0{\cdot}108 : 0{\cdot}815 = 1 : 7{\cdot}6 = 1 : 8$

Hence the formula:

$$Na_4 R R_2 Si_8 O_{25}$$

$$\left\{ \begin{array}{l} 2\ Na_2 SiO_3 \\ R\ SiO_3 \\ R_2 Si_5 O_{16} \end{array} \right\}$$

wherein $Ca : Fe = 2 : 3$ $\quad$ $Al_2 : Fe_2 = 1 : 11$

hen:

$8\ SiO_2$	=	480	SiO_2	49·03
$2\ R_2O_3$	=	310	R_2O_3	31·66
RO	=	65	RO	6·64
$2\ Na_2O$	=	124	Na_2O	12·67
		979		100·00

The ægirine examined is therefore a mixture of bisilicates, in which, owever, the sesquioxides form a basic salt.

The analysis of *Rammelsberg*, which does not at all agree with *Pisani's* r with *Rube's* leads to the formula.

$$\left\{ \begin{array}{l} 6\ Na_2 SiO_3 \\ 10\ R\ SiO_3 \\ 5\ Fe_2 Si_2 O_9 \end{array} \right\}$$

The small quantity of soda and the large quantity of lime are striking; erhaps therefore it may be supposed that the substance used for his alysis was not very fresh.

V. Sodalite.

Literature of the Greenland sodalite: Ann. of. phil. I, 104 (Ekeberg) Gilbert's Ann. 39, 127 and 40, 98 and Journal des Mines 1811 (Thomson). Pogg. Ann. 109, 576 (Rammelsberg.)

Sodalite was first found in Greenland, and was by the *Count de Bournon* considered to be a green felspar; in 1811 the mineral was named by *Thomson* with especial regard to the great quantity of soda contained in it. He finds in the mineral two p. ct. of water, but only a small quantity of chlorine, which shows that the substance analysed by him cannot have been either very pure or fresh. I give the analyses of *Thomson* (I) and *Ekeberg* (II) together with an analysis of an unaltered sodalite from Ilmengebirge by *G. Rose* and *E. Hofmann* (III) for comparison with mine.

	I.	II.	III.
SiO_2 ..	38·52 ..	36·00 ..	38·40
Al_2O_3 ..	27·48 ..	32.00 ..	32·04
Fe_2O_3 ..	1·00 ..	0·25 ..	—
CaO ..	2·70 ..	— —	0·32
Na_2O ..	23·50 ..	25·00 ..	24·47
Cl ..	3·00 ..	6·75 ..	7·10
Loss by heat	2·10 ..	— ..	—
	98·30	100·00	102·33

Obviously the analysis of *Ekeberg* was made on a fresher substance than *Thomson's*, but it cannot be quite correct, as it does not show any surplus.

The sodalite is always coloured green, which under the microscope is seen to arise from an intermixture of microscopical crystals of arfvedsonite. The crystals are dodecahedra, imbedded in arfvedsonite or felspar, less frequently in eudialyte, and form, especially in the last case, a very beautiful rock.

The size of these dodecahedra is generally equal to that of a pea. The Museum however possesses some broken specimens, which are an inch in diameter; these are imbedded in felspar.

The fracture is conchoidal, with a vitreous lustre; the cleavage faces are parallel to the planes of the dodecahedra.

Hardness=5·5—6. Specific gravity=2·31.

Before the blowpipe it does not fuse so easily as the Vesuvian sodalite, and becomes grey and opaque.

At first it seemed somewhat difficult to isolate the substance, but I always preferred to take the sodalite which was imbedded in arfvedsonite, these two minerals being distinctly separated through the difference in colour. Still a complete separation is impossible, the sodalite, as above

nentioned, being penetrated with microscopic crystals of arfvedsonite, but fortunately also unnecessary, as on solution in hydrochloric acid the whole quantity of felspar and of arfvedsonite remain unaltered and can be filtered from the solution.

If the mineral be dissolved in nitric acid, the chlorine can very easily be determined; there are but one or two milligrams of silica precipitated with the chloride of silver. The analysis yielded the following result:

		Quotients.	
SiO_2	36·50	0·608	0·608
Al_2O_3	31·53	0·306	0·309
Fe_2O_3	0·19	0·003	
CaO	0·25	0·004	0·430
Na_2O	26·30	0·424	
K_2O	0·18	0·002	
Cl	7·30	0·206	0·206
	102·25		

then

$$Na : Cl = 0{\cdot}848 : 0{\cdot}206 \qquad Al_2O_3 : SiO_2 = 0{\cdot}309 : 0{\cdot}608$$
$$= 4{\cdot}1 : 1 \qquad = 1 : 2$$

$$Na_2 : Al_2 = 0{\cdot}424 : 0{\cdot}309$$

If the quantity of sodium contained in Na Cl be subtracted, we have:

$$Na_2 : Al_2 = 0{\cdot}319 : 0{\cdot}309$$
$$= 1 : 1$$

and obtain the formula

$$\left\{ \begin{array}{c} 2\ Na\ Cl \\ 3\ Na_2\ Al_2\ Si_2\ O_8 \end{array} \right\}$$

the same as stated in *Rammelsberg's* Mineralchemie. The formula yields the following result:

6 Si	= 168	SiO_2	37·08
3 Al_2	= 163·8	Al_2O_3	31·71
8 Na	= 184	Na_2O	25·55
24 O	= 384	Cl	7·31
2 Cl	= 71		
	970·8		101·65

VI.—Nepheline.

The Greenland Nepheline is found at Naujakasik and Siorarsuit Tunugdliarfik, on the northern side of Nunasarnausak, and at Angerdluarsuk: it has not till now been examined. It occurs crystallized in hexagonal prisms, terminated by the basal pinacoid; and very seldom in combination with small planes belonging to the first pyramid. The crystals are greyish white or greenish, in the last case translucent on the edges; they are seldom larger than a hazel-nut, and frequently smaller; the surface is coated with small shining laminæ of mica. It also occurs massive, closely connected with arfvedsonite and felspar,

and very much resembling sodalite. In this form it was found on a specimen from which in the course of time part of the nepheline had disappeared, leaving in the ground mass of arfvedsonite and felspar, larger and smaller cavities, the form of which reminded of crystals of sodalite, so that I considered it to be sodalite until I had analysed the mineral. This mineral however sometimes has pretty distinct cleavage-faces, and, if these are missing, a sort of conchoidal fracture,—the conchoidal face being very small,—which has vitreous lustre; on the other hand, on the nepheline I have never seen distinct cleavage-faces, but an uneven or splintery fracture and a greasy lustre. To decide whether a specimen be the first or the second, it is always sufficient to to dissolve a bit in nitric acid and search for chlorine.

The specific gravity of the crystal used for analysis I, was 2·60, that of the massive mineral 2·63. Moreover it must be remarked, that, although the crystal also contained a small quantity of arfvedsonite and felspar, the massive mineral contained thrice as much. In the first analysis, the crystal did not yield substance enough for the determination of the water. The second analysis was made on the massive mineral. Of course the alumina was in both cases purified from silica. The following results were obtained.

	I.	Quotients.	II.	Quotients.
SiO_2	43·39	0·723	41·87	0·698
Al_2O_3	32·28	0·313	33·94	0·335
Fe_2O_3	0·92	0·005	0·70	0·004
CaO	0·70	0·012	0·47	0·008
K_2O	5·62	0·060	6·68	0·071
Na_2O	16·52	0·266	15·03	0·243
Cl	Trace		Trace	
Loss by heat	——		0.94	
	99·43		99·63	

There is some difference between the analyses. Perhaps it might be supposed that, when the nepheline in II was dissolved in hydrochloric acid, a small quantity of silica had remained with the felspar and arfvedsonite, and had been filtered from the solution along with these. In fact, the whole residue was more unhesitatingly set down as undecomposed mineral, because at the beginning of the analysis I supposed the mineral to be altered sodalite, whith might be fully and easily dissolved in hydrochloric acid. I will therefore take both minerals into consideration when calculating the formula.

	$R_2 + R_1$	:	Si	R_2	:	R	K	:	Na
I	0·656	:	0·723	0·338	:	0·318	0·060	:	0·266
	= 1	:	1·1	1·06	:	1	1	:	4·4
II	0·661	:	0·698	0·322	:	0·339	0·071	:	0·243
	= 1	:	1·05	1	:	1·05	1	:	3·4

If we venture to change the ratio to :—

$R + R : Si = 1 : 1 \quad R_2 : R = 1 : 1 \quad K : Na = 1 : 4$

It will afford the plain formula.

$$R_2SiO_3 + Al_2SiO_5 = R_2Al_2Si_2O_8$$

And the composition will be

$2\ SiO_2$	= 120·	SiO_2	= 41·18
Al_2O_3	= 103·	Al_2O_3	= 35·35
$\frac{1}{5}\ K_2O$	= 18·8	K_2O	= 6·45
$\frac{4}{5}\ Na_2O$	= 49·6	Na_2O	= 17·02
	291·4		100·00

The above formula is the same which *Rammelsberg* formerly admitted, but has now given up. It is exactly the same as that of the silicate in sodalite, while the formula which *Rammelsberg* prefers is that of the silicate in sodalite-leucite. It is true that in the formula here used there is the drawback that it gives too small a quantity of silica and too much of the bases, but on the other hand it seems preferable on the ground of simplicity.

VII.—Eudialyte.

Literature: Crells chem. Ann. I, 493. 1801 (Trommsdorf). Gilbert's Ann. 13,491. 1803 (Gruner) and 63,379. 1819 (Stromeyer). Schweigger's Beiträge z. Chem. u. Phys. 29,1. 1820 (Pfaff). Pogg. Ann, 63, 142. Oefvers. Sv. Vet. Ak. Forh., 1845, 37 (Svanberg).—Comptes Rendus 43, 197 (Damour).—Acta. Univ. Lund. II., 1—25, 1870 (Nylander).

Eudialyte, which on account of its colour and whole appearance, resembles somewhat both garnet, and zircon, was first examined by *Trommsdorf*, who, in 1801 found Zirconia in it, and gave it the name "dichter Hyacinth." A few years later *Gruner* mentions, that the Prince *Galitzin* has referred it to coccolite, which recently had been discovered by *Abildgaard*, but to that *Gruner* objects, since coccolite contains manganese dioxide, eudialyte zirconia. He proposes the name "blättrige-Hyazinth," although the mineral in the title of his paper is called "der rothe blättrige Granat aus Groenland." In 1819 finally *Stromeyer* made an analysis more trustworthy than the previous ones, and called it by the name of eudialyte, because it is easily dissolved in acids; and this name has remained unaltered. A contemporaneous analysis was instituted by *Pfaff*, but all these analyses are now superseded by newer ones, instituted by *Rammelsberg* (I), *Damour* (II), and *Nylander* (III).

	I	II	III
TaO_2	——	0.35	——
SiO_2	49·92	50·38	51·86
ZrO_2	16·88	15·60	14·67
FeO	6·97	6·37	6·54
MnO	1.15	1·61	1·46
CaO	11·11	9·23	9·82
Na_2O	12·28	13·10	12·32
K_2O	0·65	——	——
Loss by heat	0·37	1·25	1·43
Cl	1·19	1·48	1·37
	100·52	99·37	99·47

In his report on an investigation of larger quantities of eudialyte, *Svanberg* mentions, but without adding a quantitative analysis, that the Greenland eudialyte contains besides the oxides of the cerium group, two other oxides, one of them resembling yttrium.

The eudialyte, as is well known, is found partly massive, partly crystallized. The crystals almost always show a great many planes. Still I have not been able to discover others than those already mentioned in the Mineralogy of *Des Cloizeaux*. The cleavage faces corresponding to $\frac{1}{4}$ R, and the base are distinct, the cleavage formerly indicated as being indistinct is not easily discovered. The fracture is granular to conchoidal, and exhibits a strong vitreous lustre.

Hardness 5·5. Specific gravity 2·85.

The streak is white, still, the powder has a faint rose colour, which is scarcely observable in the streak.

Before the blowpipe it fuses pretty easily to a green glass. When treated with acids it gelatinizes, evolving a distinct odour of sulphuretted hydrogen.

Three analyses were made besides two determinations of chlorine and two of water. To determine the chlorine I distilled the mineral with diluted sulphuric acid, and precipitated the chlorine in the distillate. The water was at first determined as loss by heat; the second time by direct weighing in a tube with calcium chloride.

The silica always contains a considerable portion of the zirconia. This was dissolved in sulphuric acid, and, after evaporation, was added to the filtrate from the silica. The filtrate was precipitated by ammonia, and the precipitate having been dissolved in hydrochloric acid, the zirconia was precipitated by sodium hyposulphite. In the filtrate the cerium oxides were thrown down by oxalic acid, and in the filtrate from the last precipitate the iron oxide by ammonia. The precipitate of the cerium oxide agreed perfectly with the usual reactions of this substance.

The result of the analysis was as follows :—

		Quotients.	
SiO_2 ..	48·63 ..	0·811 }	0·930
ZrO_2 ..	14·49 ..	0·119 }	
FeO ..	5·54 ..	0·077 }	
MnO ..	0·42 ..	0·006 }	
CeO (LaO, DiO)	2·27 ..	0·021 }	0·297
CaO ..	10·57 ..	0·189 }	
MgO ..	0·15 ..	0·004 }	
Na_2O ..	15·90 ..	0·256	0·256
K_2O ..	trace ..	—	
Cl ..	1·04 ..	0·030	0·030
Water ..	1·91 ..		
	100·92		

Then Cl : Na = 0·030 : 0·512 = 1 : 17·1

Na_2 : R = 0·256 : 0·297 = 0·86 : 1

If the NaCl be substracted = 0·8 : 1

Or approximately = 1 : 1

R : (Zr,Si) = 0·297 : 0·930, Zr : Si = 0·119 : 0·811

= 1 : 3·1 = 1 : 6·8

This ratio affords tolerably correctly the formula :

$$NaCl + 8\ Na_2\ R\ (Si,Zr)_3\ O_8$$

or

$$8 \left\{ \begin{matrix} NaCl \\ Na_2\ (Si,\ Zr)_2\ O_5 \\ R\ \ (Si,\ Zr)\ O_3 \end{matrix} \right.$$

Further we have :

Ce : Ca = 0·021 : 0·189. Fe : Ca = 0·077 : 0·189

= 1 : 9 = 1 : 2·5

The formula differs somewhat from that which may be deduced from the analyses of *Rammelsberg* and *Nylander*, (with which that of *Damour* does not agree), according to whom eudialyte has the following composition :—

$$6 \left\{ \begin{matrix} NaCl \\ Na_2\ (Si,\ Zr)_2\ O_5 \\ R_2\ \ (Si,\ Zr)\ O_5 \end{matrix} \right.$$

containing a much smaller quantity of soda, but more zirconia and silica, which perhaps is owing to a less fresh substance.

VIII.—Lievrite.

The Greenland Lievrite* here described for the first time, occurs both massive and crystallized. The colour is in both cases dark; the crystals are quite fresh and show an intense metallic lustre. They occur in highly striated prisms, the terminal planes are often missing, because the crystals have grown to other minerals; but are also

* On the occurrence of lievrite and lepidolite in Greenland, see the remarks of Prof Johnstrup, p. 69

frequently well developed. The common combination is $\infty \breve{P} \infty$, $\bar{P} \infty$, $\frac{3}{2} \breve{P} \infty$ connected with some more indistinct prisms. Besides the brachydome $\frac{3}{2} \breve{P} \infty$ is commonly seen a curved plane, continuing the pinacoid—consisting of some more brachydomes. On several crystals is the fundamental pyramid associated with these in very small planes, commonly striated parallel to the long polar edge, and in this case not to be accurately measured; I therefore give but one measure, taken from the most distinct crystal. All the angles were measured by the reflecting goniometer, and have yielded the following results, with regard to which it should be remarked that the prismatic angle could not be measured exactly on account of the striation, and therefore I do not state its measurements.

			Des Cloizeaux
$\bar{P} \infty$: $\bar{P} \infty$	=	112°46′—112°49′	112°49′
$\frac{3}{2} \breve{P} \infty$: $\frac{3}{2} \breve{P} \infty$	=	96°6′	96°57′
P : P	=	139°29′	139°31′

Often the crystals are twins, with the brachy-pinacoid the composition-face. The streak and powder are coal black.

The hardness is 6, parallel to the longer-axis of the crystals, vertically to this direction, 5·5. Specific gravity 4·05.

Before the blowpipe the mineral fuses pretty easily. Is easily dissolved in acids.

When heated in a small combustion-furnace, it lost only a small quantity of water. As late analyses by *Sipoecz*† and *Staedeler*‡ have shown contrary to the previous supposition, that lievrite contained water chemically combined, it was necessary to see if this could be admitted for the Greenland lievrite. The crystals which were at my disposal were excellently fit for this investigation, being intensely shining and showing a fresh dark fracture; that these should have taken up water in consequence of some alteration, seemed altogether impossible. Two examinations were made; the first time the lievrite was heated in a platinum tube, the second time in an iron tube well heated beforehand in a combustion furnace; both tubes were about $\frac{3}{8}$ inch in diameter and eighteen inches long. The powdered lievrite was placed in a small platinum boat and introduced in the tube, which was now heated before the blowpipe, while a current of dry air passed through the tube. The water expelled was collected in a tube filled with calcium chloride and weighed. This method is the same as that which was used by *Sipoecz*. I found respectively 1·71 and 1·90 p.ct. of water. When heating the last time, I obtained a higher temperature, and I therefore think the figure 1·90 is to be preferred.

† Tschermak, Mineralog., Mittheilungen 1875, 71.
‡ Journal f. prakt. Chem. 99, 70.

The result was as follows :—

		Quotients.	
SiO_2 ..	29·30 ..	0·488 ..	0·488
Fe_2O_3 ..	20·30 ..	0·127 ..	0·127
FeO ..	33·50 ..	0·465	0·493
MnO ..	1·97 ..	0·028	
CaO ..	13·71 ..	0·245 ..	0·245
Loss by heat	1·90 ..	0·106 ..	0·106
	100·68		

Then $Ca : (Fe\,Mn) : Fe_2 : Si = 0{\cdot}245 : 0.493 : 0{\cdot}127 : 0{\cdot}488$

$= 1{\cdot}94 : 3{\cdot}9 : 1 : 3{\cdot}84$

$= 2{\cdot} : 4 : 1 : 4{\cdot}$

and $H_2 : Fe_2 = 0{\cdot}106 : 0{\cdot}127$

$= 1 : 1{\cdot}2$

This ratio affords the formula :—

$$\left\{\begin{matrix} 2\ Fe_2\ Si\ O_4 \\ Ca_2\ Si\ O_4 \\ Fe_2\ Si\ O_5 \end{matrix}\right\} + H_2\,O$$

or $H_2\ Fe_4\ Fe_2\ Ca_2\ Si_4\ O_{18}$

Whence the following composition is deduced :—

4 Si O_2	= 240 ..	Si O_2 ..	29·34
$Fe_2\,O_3$	= 160 ..	$Fe_2\,O_3$ ..	19·56
4 Fe O	= 288 ..	Fe O ..	35·21
2 Ca O	= 112 ..	Ca O ..	13·69
$H_2\,O$	= 18 ..	$H_2\,O$ ..	2·20
	818		100·00

The above formula is the same which the analyses of *Sipocz and Staedeler* yielded.

IX.—Lepidolite.

Lepidolite occurs together with ægirine, arfvedsonite, eudialyte, sodalite, and the following mineral at Kangerdluarsuk. It here exhibits two axes of double refraction. The colour is white, it forms very shining laminæ, in several places intermixed with very small crystals of ægirine, in other places quite pure. The hardness is 2·5, the specific gravity 2·81.

When heated, it fuses very easily (in a candle-flame) to a white bead and communicates to the flame a red colour. It is not decomposed by acids, not even by boiling concentrated sulphuric acid. It contains water in great quantity, but no fluorine. For this I have carefully searched by fusing the mineral with sodium carbonate, and proceeding in the usual way. When calcium chloride had been added, a small precipitate was obtained, but it proved to be only carbonate of calcium.

The lepidolite used for the analysis was extremely pure. The beginning of the analysis was conducted in the usual manner. The

alumina being precipitated, the filtrate contained the sulphates of the alkalies. When by evaporating and heating they had been separated from the salts of ammonia, they were dissolved, and the sulphuric acid was precipitated by calcium-chloride and alcohol. In the filtrate the lime was precipitated by oxalic acid, and the alkalies were weighed as chlorides. The chlorides were treated by a mixture of ether and absolute alcohol. The lithium chloride being thereby dissolved, the chlorides of sodium and potassium, remaining as residue, were separated by platinum tetrachloride.

To determine the quantity of water I heated the lepidolite before the blowpipe flame; as no fluorine was present, all the loss by heat might be set down as water. The lepidolite only very slowly lost all its water; until the 13th weighing I did not obtain a constant weight; the mineral had then been exposed to the heat for altogether 5 or 6 hours. In the crucible it fused instantly to clear beads of a vitreous lustre.

The result of the analysis was:—

$Si\,O_2$	..	58·93	..	——	..	58·93	..	0·982	0·982
Al_2O_3	..	12·87	..	12·79	..	12·83	..	0·125	0·132
Fe_2O_3	..	1·04	..	1·18	..	1·11	..	0·007	
K_2O	..	——	..	5·37	..	5.37	..	0·057	0·482
Na_2O	..	——	..	7·63	..	7·63	..	0·123	
Li_2O	..	——	..	9·07	..	9·07	..	0·302	
Loss by heat		——	..	4·99	..	4·99	..	0·277	0·277
						99·93			

Then:—

$$Si : Al_2 : R_2 : H_2 = 0{\cdot}982 : 0{\cdot}132 : 0{\cdot}482 : 0{\cdot}277$$
$$= 7{\cdot}4 : 1 : 3{\cdot}7 : 2{\cdot}1$$

If we may assume the ratio to be:—

$$7 : 1 : 4 : 2$$

It will afford the plain formula:—

$$\left\{\begin{matrix} 4\ R_2\ Si\ O_3 \\ Al_2\ Si_3\ O_9 \end{matrix}\right\} + 2\,H_2O$$

Wherein $K : Na : Li = 1 : 2 : 5$.—

The formula shows this lepidolite to be a hydrate of bisilicates, but it does not, it is true, agree fully with the composition obtained by the analysis:—

$7\,Si\,O_2$	=	420	..	$Si\,O_2$	..	56·53
Al_2O_3	=	103	..	Al_2O_3	..	13·86
$\frac{1}{2}\,K_2O$	=	47	..	K_2O	..	6·34
Na_2O	=	62	..	Na_2O	..	8.34
$\frac{5}{2}\,Li_2O$	=	75	..	Li_2O	..	10·09
$2\,H_2O$	=	36	..	H_2O	..	4·84
		743				100·00

This lepidolite has thus been proved to contain a much larger quantity of silica than the species of mica formerly known, and less than half of the quantity of alumina usually contained in lepidolite. Further, it contains unusual quantities of alkalies and of water, while the fluorine, which has been found in all other lepidolites, is wholly wanting.*

X.—Steenstrupine.

The analysis of this mineral has shown it to be a new species, and, as suggested by Prof. Johnstrup, I have therefore given it the name of *Steenstrupine*, after Mr. *Steenstrup*, who not only first found the mineral, but to whom the Museum is also indebted for the acquisition of excellent specimens of the numerous and rare minerals from the Julianehaabs district.

The mineral has a brown colour, a faintly brown, almost white, streak, The hardness is 4, and the specific gravity 3·38. It is pretty easily fused before the blowpipe to a grey, dull bead. Occurs massive and crystallized, together with lepidolite and ægirine in the sodalite-syenite at Kangerdluarsuk.

The crystals are almost always curved, or appear as if they were gnawed off both on the edges and on the planes; only on two small crystals have I been able to observe tolerably distinct planes and edges of combination. They have a certain resemblance to the crystals of eudialyte, and seem to be combinations of a rhombohedron and the basal pinacoid; to these, on the above mentioned two small crystals, there are associated a second positive rhombohedron, and perhaps more than one negative. The angle between the base and the fundamental rhombohedron could not be accurately measured, but was found to be about 128°. As in eudialyte, it is 112° 18′, the two minerals cannot by any means be connected.

The chemical composition being somewhat intricate, I shall give a detailed account of the analysis. The mineral seems to be totally decomposed by acids; however, as it always contains a small quantity of ægirine, which cannot be separated from the silica, I preferred to treat the mineral as if it was not decomposable by acids. I made a single separate determination of the silica, and three analyses; in one of these the mineral was decomposed by carbonate of sodium, and in two by hydrofluoric acid.

* Compare *Reuter's* analysis of the lepidolite from Rozena: Fl 4·86, SiO_2 50·43, Al_2O_3 28·07, $'Mn_2'O_3$ 0·88, Mg.O, 1·42, K O 10·59, Na_2 O 1·46, Li_2 O 1·23,—98·91, *Rammelsberg*, Mineralchemie 1875, 521.)

The *silica* had a red-brown colour, somewhat resembling that of silica containing iron oxides. After having been heated it was brownish and proved to be extremely impure; 0·2795 gr. was once mixed with 0·234 gr. of the bases (total weight = the impure silica = 0·5135 gr.). The bases on being heated by themselves, were of a dirty grey colour, after cooling, brown. They were dissolved in sulphuric acid, except a small in soluble residuum, and the solution was added to the filtrate from the silica.

Decomposition by hydrofluoric and sulphuric acid.—The mineral was totally decomposed and dissolved, except a small residue, which before the blowpipe in a bead of ammonium-sodium phosphate remained uncoloured; it was further insoluble in sulphuric acid, and was supposed to be tantalic acid. The solution was precipitated with ammonium sulphide, the precipitate dissolved and again precipitated.

The precipitate was now dissolved in hydrochloric acid, which was expelled by sulphuric acid and concentration. The oxides of the cerium-group were then precipitated by sodium sulphate. The filtrate from this precipitate, being a concentrated solution of sodium-sulphate, was precipitated by ammonium-sulphide and the precipitate dissolved. The solution was boiled with sodium acetate, after which only the *manganese* remained in solution; this was determined in the usual manner. In the precipitate thorium and iron were separated from the *alumina* by soda. The *thorium* and *iron* were separated from one another by hyposulphite of sodium.

I have tried to separate the oxides of the cerium-group, in all the analyses, by the method of *Gibbs* (American Journ. 37, 252. 1864), according to which the oxides are oxidized by nitric acid and lead dioxide. Thereupon the basic salts are produced by warming and treated with water containing a small quantity of nitric acid, when the salts of lanthanum and didymium are dissolved, the cerium salt remaining.* I did not find the method practical, especially because it is at times almost impossible to filter the solution from the basic cerium salt. If the solution contains a certain quantity of lead nitrate, the filtration proceeds somewhat easier. For the rest I may remark, that after having been heated, the oxides of lanthanum and didymium were easily dissolved in water containing a drop of nitric acid, but the cerium oxide only when warmed with sulphuric acid, whereas when mixed together, as they were before the separation, they were easily dissolved in hydrochloric acid.

* Before this operation the sulphates of sodium and cerium, etc., were dissolved; the solution was precipitated by oxalic acid and the oxalates, when heated, dissolved in hydrochloric acid, which finally was expelled by nitric acid.

The quantity of alumina is doubtful, some of it being always dissolved in hydrochloric acid with a yellow colour, which I have not been able to explain.

The *thoria* yielded the following re-actions :—

[1] With *tannic acid*, no precipitate and no colour,

[2] With *zinc and sulphuric acid*, no precipitate and no colour,

[3] With *oxalic acid*, a white, heavy, granular precipitate ; *all* was precipitated even in a very acid solution.

[4] With *ammonia*, a white, bulky precipitate.

[5] When boiled the solution yielded a granular precipitate, which after cooling was again dissolved.

The two first reactions show that no titanic acid is present, the third that there is no zirconia, and, together with the fifth, that the substance must be thoria.

I have further searched for chlorine and fluorine, which were found not to be present. When determining the water I first dried the mineral over sulphuric acid, after which it lost 0.95 °/₀ water at 100°. The remaining water was expelled in a combustion furnace and weighed directly in a tube with calcium chloride, as the loss by heat above had proved to yield too small a figure, on account of the peroxidation of the mineral.

The analysis yielded the following result :—

SiO_2	27·95
TaO_2	0·97
Fe_2O_3	9·71
Al_2O_3	2·41
Th O	7·09
MnO	4·20
Ce O	10·66
La O, Di O	17·04
Ca O	3·09
Na_2O	7·98
H_2O	7·28
	98·38

As the separation of thoria from the oxides of the cerium-group which is effected by sodium sulphates is not exact, and as moreover the composition of the mineral is very intricate, I shall not attempt to deduce any formula, until more analyses have been instituted.—

Prof. *Johnstrup* has kindly communicated to me the following remarks on the occurrence of lievrite and lepidolite in Greenland :—

On examination of the minerals, which in 1874 had been brought home from Ilugdliarfik and Kangerdluarsuk by *Mr. Steenstrup*, I perceived, that besides the Arvedsonite and ægirine a third mineral was present, which differed somewhat from

the others as to crystallization, lustre and specific gravity. An analysis convinced me, that it was *lievrite*. As I have informed you, that this mineral had not previously been found in Greenland, though the contrary has been stated in several works on Mineralogy, I think it necessary to account for this apparent contradiction, even if this rather unessential question should thereby be treated somewhat more at length than I wished to do.

When *Dr. Rink* names lievrite amongst the "doubtful Greenland fossilia,"* it is not without reason; for in the collections of Greenland minerals, which *Giesecke* in the years 1814, 1817, and 1818 sent to the Copenhagen Museums, is only found a single specimen which might contain this mineral. The label says: "Jenait (ought to be Jenit or Yenit) mit Granat, in Granit von Kangerdluluk." Giesecke does not however mention it in his Journal, and therefore cannot have attributed much weight to this occurrence. As probably there have been similar specimens from this locality in the collections which he supplied to the foreign museums, it is easily explained that *Leonhard* in his "Handbuch der Oryktognosie, 1821," amongst the lievrite localities also mentions *North Greenland (Kangerdluluk, mit Granaten in Granit?)* whence it was adopted in his son's "Handwörterbuch der topographischen Mineralogie."

To Leonhard the correctness of this statement may have seemed doubtful, which the sign of interrogation sufficiently shows, and an examination which I undertook of the specimen named, also proved it only to contain amphibole, not lievrite. As upon the whole he deposited the finest specimens in the Copenhagen Museums, there can hardly be finer ones abroad. Therefore the lievrite ought not to be considered as a Greenland mineral till 1874, as till then there had never been pointed out any other occurrence than that above mentioned.

When *Des Cloizeaux* in his Manuel de Minéralogie (1862) in the section "Ilvaite" does not mention *Kangerluluk* (North Greenland) but *Kangerdluarsuk* (South Greenland), he has probably been mistaken about these two localities, the latter being better known on account of its rare minerals. Hence also *Dana* may have adopted this occurrence in the fifth edition of his Mineralogy (1868), while it is not mentioned in the fourth edition (1854). It is then a remarkable case, that the first locality where the lievrite really has been found in Greenland, is the same, which has been given by mistake, while the locality originally stated, viz: Kangerdluluk in North Greenland, should now disappear from the catalogues.

With regard to the *lepidolite*, which in your paper is stated to be new for Greenland, it ought to be remarked that *Giesecke* in his journal† says, that he found it in the immediate neighbourhood of Julianehaab, but, as I have remarked in a note, from this locality it is not found either in the Copenhagen or the Dublin collections. A lepidolite from Kangerdluarsuk he does not at all mention, although it is found in small quantities on the sodalite-syenite brought home by himself. Probably he has thought it to be a common potassium-mica.

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* *Rink*: Groenland geographisk og statistisk beskrevet. Tillœg, p. 152.

† *Giesecke*: Mineralogisk Rejse i Groenland. Kjoebenhavn, 1878, p. 16.

The Geognosy and Mineralogy of Scotland.

By Professor Heddle.

SUTHERLAND.—Continued.

The Upper Gneiss.

WHILE agreeing with those writers who affirm that many of the members of this series are of the nature of schists,—sometimes almost flaggy schists, still, even when examined throughout their multitudinous varieties, it has to be affirmed that they are all *gneissic* schists; and, however fissile some of these members may be, this is far from a sufficient reason for attempting to dispense with a time-honoured appellation;—one moreover which is more fittingly applied to them, than to the somewhat *more generally hornblendic* rock to which alone it has been proposed to confine its use.

As perfect a gneissic structure, nay, even a more perfect gneissic structure is to be seen in the rocks between Tongue and Farr,—in Strath Oikel, or at Strath Virick, as in any part of the "hornblendic gneiss"; and the gradual transition of such rocks (generally as we ascend on the series,) into readily cleavable flat flags,—whether gritty, micaceous, or aluminous,—shews the latter to be but lithological allomorphs.

Changes quite as marked, both as regards proportional increase of one or other ingredient, and as regards structural modifications, are found to obtain in this upper system of rocks, when we track them *along their strike;*—even when we are kept rigidly thereto by restricting ourselves to an examination of that basement layer which is in contact with, or immediately succeeds to the upper quartzite.

Sooth to say, it becomes very much of an enigma, if we suppose that layer to have been deposited upon anything approaching to a level ocean-floor, how rocks so very dissimilar as those which we find in different districts along this line, can have been simultaneously laid down.

Over the quartzite at Whiten Head, may be seen at the Bodach-berg, a dark-green rock, coarse in structure, and largely formed of what

was possibly hornblendic mud. This rock is generally so similar to parts,—especially to decomposed parts of the hornblendic gneiss, that it is not altogether to be wondered at that they were at one time considered to be the same.

This Whiten Head rock has by one observer been called "chloritic schist."

While it is *chloritic* in the sense of being *green*, it certainly is very different from the true chlorite-slate of Ben Lomond, and the south-west of Scotland. The colouring ingredient seems to be a mixture of pounded hornblende with minute scales of muscovite. Very possibly it is a repetition in force, of the schistose green beds which at many points underlie the Logan rock.

As we pass southwards we come, in the neighbourhood of Hope Lodge, to beds of a quartzose character. These, considered along with others which lie between the Hope Ferry and the limestone of Heilim, may be taken as supplying fair ground for holding *that the quartzite there passes upward by a system of separated beds into the upper gneiss;* and as entitling us to refer both to the same epoch.

The uppermost of these beds lies about a fourth of a mile to the east of the Lodge, and it differs markedly from the rock last noticed. It might, from its extremely schistose character, be termed *paper quartz*. Its appearance, which is somewhat that of a mica-schist deprived of its mica, conveys the impression that it is an example of pseudomorphism in a rock mass.

Still further southward, an increase in the quantity of mica beyond that of the Bodach-Derg Rock, gives us the "Oyster Shell Rock" of Craig Vercan. This larger amount of mica is here asserting itself in the attempt to form crystals; but the associated hornblendic mud, may, by distorting these, have produced the curvilinear "oyster-shell" structure.

Still further south, the total removal of the dark-coloured ingredient gives us, at Leiter Mussel, a mica-slate, which cleaves into plates as thin as a writing slate. In the Loch More and Loch Merkland district, it has become a clay-slate, dark in colour, merely glistening with mica;—not far from the *phyllade* of the French.

On the eastern side or end of the ridge of Ben More, there is so small an amount of the sand-grains that the rock, when wet, works into a plastic clay. East of Loch Ailsh, the silica has returned in such quantity and with so much coherence, that some would term the flags quartzite.

On the road between Knockan and Ullapool, it looks like a clay-slate, with some bands largely made out of a mud of comminuted horn-blende: while, south of Loch Broom, down to Fionn Bheinn (Ben Fin), and away to the south-west, the mica in predominating amount has again come back in glittering scales of yellowish muscovite, studded with garnets and interlaminated with quartz;—the veriest gneiss of all the range.

The line is a fairly straight one now, with no great amount of vertical undulation; but when it formed the sea-bottom, it may have lain in wrinkles: and at present we can only speculate as to how much of this local segregation of these dissimilar materials may have been due to substances of higher gravity settling first in the deeper pools;—and how much to slight differences or intensities of a local metamorphism, which produced different results from elements occasionally differing but little, if at all.

The marked dissimilarity of the rocks which immediately overlie the quartzite in Sutherland proves that, in attempting correlations in a country, it will not suffice to make an eight or ten mile section across a series of rocks;—a traverse of a hundred miles, keeping faithfully to the strike or along the junction, is also imperatively called for.

Although neither typical chlorite-slate, mica-slate, nor clay-slate, occurs among these rocks, the marked difference in their structure and composition, shews the wide range in lithological character and in mineral composition, which may occur in the members of one formation; and also testifies to the impropriety of any attempt to set aside a long-established name upon the merely-local features of one of its members. The proposal to dispense with the term "gneiss" as applied generally to the members of this formation, is therefore, on every ground of scientific nomenclature, to be deprecated. It was *to this very class of rocks* that the term was first applied in Scotland, and has ever been applied; we may indeed doubt if those who introduced it ever saw saw that "Hebridian gneiss" to which it is now proposed to restrict its use. Should the progress of discovery necessitate a distinctive term, such term must be applied to the rock which, in virtue of its dissimilarity to the recognised type, calls for an extended nomenclature; and the confusion which could not but have ensued from the adoption of any other principle in the present case (and which in point of fact has ensued) quite called for Nicol's remonstrance, that "it would take more arguments than had been brought forward, before he

could be induced to believe that Jameson and Maculloch, Boué, and Necker, did not know gneiss when they saw it." *

Minerals.

These occur not only in much greater numbers and variety, but are markedly different in what may be termed *type*, from such as I have above recorded as having been found in the hornblendic gneiss.

From the very varying basement layer of the upper gneiss, I procured minerals in but one spot. This was from the mica-slate. The locality was the foot of a line of cliff called Leiter Mussel; this is a south spur of Ben Hope.

At the north end of this cliff we (D. & H.) got garnets in rhombic dodecahedral crystals; these were sometimes formed of successive layers of garnet, with bands of grains of silica,—in fact glistening sand. These bands though composed of a mechanical debris, had been so under the control of the accession of each new layer of garnet, as to have been caught up or pushed before it, whilst the material of that layer was being drawn to the common centre of the crystalline action.

* That no very marked petrological distinction can be drawn between the two classes of rocks, may be shown by quoting from the writer who most urgently insisted upon the change of name.

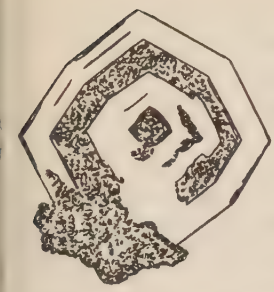
Sir R. Murchison in 1858, writes—"we ascertained that Farrid Head consists of the old gneiss." In 1859, he writes "that promontory was erroneously referred to the old gneiss in my former memoirs, on conclusions drawn from a hasty visit of my friend Mr. Peach, who brought me specimens from one part of the headland, which had a gneissose aspect."

One of two conclusions must be drawn from this—either, that the *haste* lay most in the writer's inferences,—or, that these specimens so strongly resembled the old gneiss, that the very geologist who was desirous of separating them, was himself unable to distinguish between them.

And yet, writing in 1861 we find Murchison again saying—"we are of opinion that no geologist can confound the fundamental gneiss with the so-called gneiss of the superior crystalline schists, which, instead of being a massive hornblendic and granitic rock, is a flag-like, micaceous, and quartzose deposit of very different character."

No strata of the upper-series are *more* "flag-like, micaceous, and quartzose" than those of Farrid Head; yet their "great dissimilarity" in character to those of the lower-rock would not appear to be so marked as to be *always* capable of ocular apprehension; and it is therefore strange that they should have formed the text for the above quoted specimen of scientific dogmatism.

The climax as regards the rocks of the Farrid is more curious still. We find in a foot note to the last paper by Murchison (Feb. 6th, 1861), that specimens of the rocks *from this promontory* were exhibited to the meeting "to show their dissimilarity to the old gneiss of Kean na bin, with which Prof. Nicol connects them." Many years ago Dr. Maculloch cynically told us that geologists had "to be taught even to see;"—does not the above entitle us to say, that we should be taught to be *slow to believe*? And what do the words "with which *Prof. Nicol* connects them" teach us,—seeing that Murchison was himself the first to make the connection?



The crystal figured *seems* to have a crystalline nucleus of granular silica:—it can hardly be conceived that the centripetal action of crystallizing molecules could induce a powder, caught up in their midst, so to arrange itself as to assume a form not belonging to the system in which its own material usually crystallised. Probably therefore there is in the specimen a minute nucleus of garnet.

This garnet has a specific gravity of 4·127.

It yielded—

Silica	35·
Alumina..	21·539
Ferric Oxide..	2·822
Ferrous Oxide	26·537
Manganous Oxide	4·461
Lime	7·107
Magnesia	2·307
Water	·143
	99·916 (H).

The rock which contained these garnets was very peculiar. *Actinolitic hornblende* of a fine colour was present in lanceolate crystals; the matrix was a snow-white granular silica of extremely high lustre,—each grain sparkling, transparent, and appearing as if quite detached from those in contact with it.

Midway between this locality and the waterfall on the Allt na Callich, crystals of *hornblende* lie sprinkled like grains of corn, in a similar matrix. Both varieties form specimens of great beauty.

Actinolite-slate occurs at both localities, in small quantity.

Inferior specimens of *chlorite* with *magnetite* occur upon the south slopes of Ben Hope.

The discovery of mineral localities in the upper-gneiss of this county must be to a large extent fortuitous:—from its vast extent it would be impossible for a single explorer thoroughly to examine it.

Dr. Joass, observing a singularly elevated ridge in the neighbourhood of Collabol, searched it, with the result of finding lamellar *baryte*, coated with *chrysocolla*.

A little to the north-west of this, a very peculiar and beautiful hornblendic-rock occurs (D. and H.).

It appears to consist of nothing but a fine granular felspar of a cream colour, containing imbedded patches of light-green fibrous *hornblende*.

Small crystals of brilliant *epidote* occur in its cavities, and also rarely, minute *sphenes*.

A well-marked hornblendic rock with a granular felspar, occurs also at the knoll called Cnoc na haire, some miles to the west;—also near Overscaig,—the whole of this district, indeed, being markedly hornblendic.

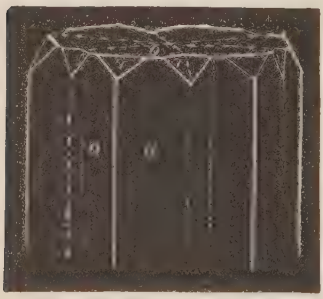
Achadhaphriz.—This is the name of a farm which lies about a mile north of Loch Shin and a little east of Collibol. During the improvements carried out by His Grace the Duke of Sutherland, the ground was here much cut into; and during the ditching the rock was in one or two spots exposed.

It was found to be a hornblendic gneiss, with a north east dip.

The *hornblende* was somewhat foliaceous, and light in colour.

The small amount of the rock which was exposed yielded, in its more felspathic portions, the following minerals.

Sphene, (D. and H.) Ill-defined and small crystals of the short flat form which is common in Scotland, occur in the more felspathic portions of the rock; they are of a pale hair-brown colour.



Apatite (D. and H). Occurs in small pale bluish-green crystals, sometimes in twinned forms as in the figure. It accompanies the sphene. Both of these minerals have here somewhat of a waxy lustre.

Minute fibres of *rutile* were associated with the apatite.

Lepidomelane (D., Jo., and H.).—This mineral, so rare in Scotland, occurs here in plates of two to three inches in length. The colour of these plates was from a yellowish-brown to a chocolate-brown. They were easily cleavable; but, as the mineral was brittle, only short flakes could be raised. It was slightly bi-axial, and had a muddy yellow-brown colour by transmitted light. The specific gravity is 2·971.

Its analysis yielded—

Silica	40·384
Alumina	12·11
Ferric Oxide	14·523
Ferrous Oxide	3·03
Manganous Oxide	3·146
Lime	1·033
Magnesia	13·
Potash	7·128
Soda	1·801
Water	3 567
	99·722 (H).

Ilmenite in thin plates was associated with the lepidomelane (D. and H).

There was found here in making the clearances, a piece of white quartz studded with small but finely formed crystals of *rutile*. Some of these crystals were in the form of the annexed figure. This was the most perfectly crystallised rutile which the writer has seen from Scotland.

Clach an Eoin.—The tract of country which lies on each side of the River Naver, and indeed the whole whole way between it and the Borgie is of extreme roughness. The gneiss seems tumbled in all directions, and is removed not only from its normal dip, but presents characters of a higher metamorphism than it displays in most parts of the county.

The rock or craggy knoll called the Clach an Eoin exhibits on its glaciated front a peculiarity of structure which I have not seen described. In comparatively feeble development something of the same kind is to be seen in the gneiss of Boggierow quarry, near Portsoy,—at Strath Virick bridge near Arguish,—and at Cunnisbay, on the Dirrymore road.

At the first, and possibly also at the second of these localities, the structure may be regarded as a mere modification, or a badly developed instance of porphyritic arrangement in the felspathic portion of the stone.

At Boggierow the crystals of the felspar, if felspar they be, are devoid of all edges and angles, appearing rather as kernels or nodules, of some half-inch or so in size. Of these there is here no definite arrangement whatever,—they are promiscuously scattered throughout the mass.

As regards the size, and want of angularity of the felspathic portions of the Innisbae rock the above also holds: but there is here no promiscuous scattering,—no absence of arrangement: these felspathic kernels lie in regular layers which accord with the micaceous lamination of the rock,—following obediently that lamination where it has been crumpled. Something very close to this is given by Cotta, as his description of typical porphyritic gneiss:—"in the otherwise uniform schistose mass there occur at intervals, large egg-shaped crystals of orthoclase (sometimes amorphous), round which the foliated texture bends itself with a wavy sweep." This description approaches it, though it is really different from, what is to be seen at Clach-an-Eoin.

The study of the Boggierow rock leaves the impression that the felspathic portion had attempted to arrange itself as crystals, or had been crystals,—porphyritically disposed. Such a conclusion will hardly apply to the Innisbae rock,—the felspathic matter is certainly not porphyritically disposed when it is confined to a regular arrangement in layers; and such a conclusion certainly will not apply at all to what obtains at the northern locality. First, it will not apply in *size*;—the individual collections of felspathic matter, to which inches would apply at the other localities, are here of the dimensions of feet and yards. Second, it will not apply as to *internal structure*; a certain amount of rough cleavage which is to be obtained in the first cases, showed that each—all being much of a size—was to be regarded as an individual mass of which the components were *its molecules*; here, nothing like cleavage is to be got; the components are crystals, granules, plates, promiscuously agglutinated, and forming masses of greatly varying size. Thirdly, it cannot apply as to *shape*; there is here no residual trace of geometric form,—for the masses are lenticular.

The strike of the rock is N. by E. and S. by W.; it stands nearly vertical; its bedding is well shown by the parallel disposition of its layers of black mica; it is singularly free from all plication; between the bedding of its micaceous layers, however, there occur in marked abundance, though at quite irregular distances, parallel arrangements of the segregated felspar of the rock, disposed like the glands on a duct, or ganglia on a nerve,—the enlargements being of ever varying size, composed each of numberless crude crystals, and hence totally different from *Augen-gneiss*.

In one respect the comparison with ganglia on a nerve is not satisfactory—the felspathic bands are generally not continuous; but the juxtaposition of the two micaceous layers which lately sheathed what I have represented under the figure of ganglionic enlargements, leads, in straight course, to the next and not far separated lenticular mass.

There can be little room for doubt that this is a modified development of that segregatory process in virtue of which the felspathic material of gneissose rocks so frequently arranges itself in layers or belts. As these belts consist of a material more plastic when heated than the less fusible quartz and mica, they are, where plicated, thinned off to nothing at the more compressed flexures, only to re-appear in ampler development among the loosened or more drooping folds. But at Clach-an-Eoin we have no plications which compress or loosen,—*the portions of the rock where the felspar thins off, being actually the least compressed of the whole;—this is seen by the opening out of the micaceous layers in the immediate vicinity.*

Can it be that metamorphism—for it is a district of considerable, though not extreme, metamorphism—has rendered the more fusible material so plastic, that cohesion has here been tugging hard to cause it to assume actually a spherical form, and has been baffled only by gravitation, which flattened out the sphere into a lens-like shape, or rather retained what, without its action, would have been a sphere, in a lens-like shape.

But the description is as yet faulty: I have used the recognised geological term "lenticular" as the adjective altogether most applicable; but the relative proportions of these masses—which vary from the size of a goose's egg to that of a grampus,—are a length about twice as great as their breadth. Since, however, they thinned away also somewhat as they merged into their connecting band, they presented an appearance so similar to that of an *eye*, that it appeared to my fellow workers, Dr. Joass and Mr. Dudgeon, that it would be most fitting that we should meanwhile designate what I have described, as an "oculitic structure."

The black mica, which so clearly defines the rock-layers, is here *Haughtonite* (D. and H.)

Towards the north-east cliff of the hill, it is to be found in plates of some inches in size; these plates protrude edgeways from the quartz-veins of the rock,—are much weather-worn,—and have upon these weathered edges the colour and lustre of somewhat tarnished metallic lead. This weather-wearing affects only the edges of the crystals, which have smooth rounded depressions with an appearance as if portions had been eaten out by some insect. There is not the smallest appearance of internal alteration or even of loosening asunder of the plates, as in the case with the mineral from Cape Wrath. These plates are associated with *garnet*, *rutile*, *ilmenite*, and *chlorite* (D., Jo., and H.). All are imbedded in quartz.

The colour of the Haughtonite is clove-brown; red-brown by transmitted light. The plates are uniaxial, or very slightly biaxial. The specific gravity is 2·96.

It yielded

Silica	35·846
Alumina	21·539
Ferric Oxide	4·467
Ferrous Oxide	18·306
Manganous Oxide	·307
Lime	1·249
Magnesia	8·076
Potash	7·759
Soda	·794
Water	1·956
	100·299 (H.)

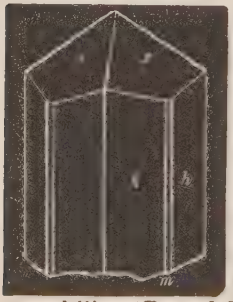
The *garnets* here occurring are quite inferior in quality and form,—they are rhombic dodecahedra of a brown-red colour.

They yielded—

Silica	39·923
Alumina	19·808
Ferric Oxide	13·69
Ferrous Oxide	13·294
Manganous Oxide	1·
Lime	9·132
Magnesia	3·307
	100·154 (H.)

When the nature of the matrix is considered, the quantity of lime is great. The *ilmenite* is in blue-black plates, and is rare; the *chlorite* is in small ill-defined rosettes of crystals.

These are all associated with the Haughtonite; on the north-east side of the hill.



The rutile occurs in single, isolated crystals, imbedded in a yellowish vein-quartz, upon the top of the Clach. The crystals are small but fairly well formed, as in the figure. Some are translucent and ruby red.

Rutile in crystals nearly two inches in length, but transversely fissured, with the matrix lodged in the interstices, occurs also in a yellow quartz, in the crags beneath a Pictish "brough," which is placed upon the south-east shoulder of the same hill. (D. and H.) The form is indistinct.

I have received through Dr. Joass portions of a rock or stone,—I believe a large boulder,—which was found in making a road at Ribigill near Tongue.

This consists of a basis of fine-grained, scaly, and very soft chlorite, (apparently); in this there are disposed in a porphyritic manner, at distances of about an inch, crystals of lustrous white *talc*, of about the size of peas.

In my experience the rock is unique. I have some hesitation in calling the one mineral chlorite, on account of its extreme softness, and from its being weathered to the depth of an inch. This is a greater amount of change than I ever saw in chlorite: it bears some resemblance to scaly saponite; but the occurrence of talc in association with saponite is unknown; as is the occurrence of saponite in sedimentary rocks. From "till," a little south-east of Tongue, I have myself got ordinary unchanged chlorite, imbedded in white quartz.

The Primary Crystalline Limestones.

These are known in Sutherland in but two localities,—the north and the south shores of Loch Shin;—at Shinness, and at Arskaig.

At these localities they present the appearance which is so usual to this rock in its higher state of metamorphism,—a congeries of crystalline particles which have mutually nullified each other's efforts to assume a regular form, and so have produced only a granular mass,—the cleavages of the several granules lying in every direction.

The primary limestones of Scotland sometimes present themselves as extremely barren of minerals; at other localities they contain a few species, which may be said to pertain to such limestones in a very special manner; while again they occasionally supply so many mineral species as to present themselves as one of the richest matrices of all rock masses. It thus becomes of interest to examine into the circumstances, and to endeavour to attain to the causes of this diversity of fruitfulness in limestones.

The first fact which is noted after the enquiry has been sufficiently extended, is that the *nature of the rock* immediately in contact with the limestone seems to have little influence; and that regard has to be had, primarily, to *the physical circumstances in which the lime is placed.*

It will be observed, that if the limestone bed is *of trifling dimensions* it will afford no minerals,—whether it be disturbed or undisturbed, convoluted or not so.

Turning the attention to the conditions and characters of the lime rock itself, it will be found that in this case it is simply *limestone*, (generally

dolomitic),—a more or less impalpable paste, amorphous in its nature, structureless, and more or less coloured or muddy, evidently through mechanical contamination.

If we look next at the including rock, it will be found that it shows no changed structure,—no greater amount of metamorphism in the vicinity of the limestone, than throughout its general mass.

It will also be observed that not only does the limestone contain no minerals, but that the strata in contact with it also afford none other than those which go to form its general mass; and that under such circumstances the crystal-dimensions of such constituent minerals is not increased.

All this *also holds*, with equal force, under the circumstances of the lime-stratum being of considerable thickness, so long as it is untroubled or convoluted.

But it is not so if the stratum be, at one and the same time, large in mass, and either itself highly-contorted, or, in those cases where it is not sufficiently exposed for this to be determined, if it be seen to be lying among highly-contorted rocks. Then, the calcareous mass no longer is amorphous in its substance; it presents itself as a *granular limestone*, often as a true marble; that is, it is *calcite*, and is crystalline in structure, and in all its inherent properties.

Here the including rock in the immediate vicinity, is much more highly metamorphosed than it is throughout its general mass; the crystalline development of its constituent minerals being not only more distinct, but more ample.

While lastly, imbedded in the limestone, and to a smaller extent in the altered rock, but in both cases near their point of contact, there are found numerous minerals which *are such as can be formed by the union of the constituents of the inclosed limestone with the inclosing rock.*

These three circumstances, then, I believe to be invariably observable with regard to the "primary limestones,"—namely, that whenever they are much folded or crumpled,—thrown at a high angle,—or when the adjoining rocks exhibit rents and fissures,—there the granular structure will show itself in the largest development of individual particles;—there simple minerals will be found in immediate association in the greatest numbers and amount;—and there the limestone will be the purest *in its own substance*, as regards both colour and translucency.

This directly points to *combination having taken place between the constituents of the rock and of the limestone*; and, if the amount of such combination be at all in the ratio of the amount of folding and contortion, it may result that the whole amount of the calcareous

matter has been taken up in such combination,—and *the limestone stratum, as such, may actually disappear.*

Local interruptions in the continuity of a limestone stratum, while a continuation of a vivid grassy verdure vouches, in these, for the presence of a large amount of calcareous matter in the rock which yields the soil, are of frequent occurrence in the Highlands.

In the bed of limestone which courses down Strath Dee, a gradual increase of the amount of imbedded mineral, (here malacolite,) and diminution of residual calcite, may be traced as we follow the bed through the constantly augmented plications to which it is subjected as it passes eastward. An average sample of the limestone taken from the Glengairn quarry, leaves after treatment in acid, about 3 p.c. of insoluble mineral. The percentage of residue increases as the stratum passes eastward along the course of the Dee. In the stone from the quarries which are opened into it as it twists about at Muir and Midstrath, there is so little calcareous carbonate that a fragment retains its shape after treatment with acid; while Dr. Young tells me that the substance which was worked and burned as lime on his property of Durris, *does not effervesce at all*, when so treated.

The most striking feature, however, is the change effected upon the rocks which are in contact with the limestone. So marked is this feature that, under the circumstances detailed, these limestones may be said *to function* in the Highlands *in a manner somewhat similar to that of igneous rocks*;—I mean as regards the changes which they seem to induce.

Such a mode of functioning is most anomalous, at first sight, as regards a substance and a structure unquestionably of organic origin; it is only to be explained through a consideration of the *circumstances* which obtain, and cannot well be assigned to the *mere presence* of limestone in a rock which is undergoing ordinary metamorphism.

Ordinary metamorphic change is, in our almost total ignorance of the subject, usually assigned to a hydro-thermal action, which has taken place at great depths, i.e., under enormous pressure. Such a thermal change should affect a plicated, and a nonplicated included rock alike; and should certainly affect a thin bed of limestone more than a thick one. As the result of any change thus pressing from *without inwards*,—that is, from the gneiss to the limestone,—we should expect to find the thinner parts of the stratum of the latter wholly converted into large granular marble, and very fully pervaded with mineral species; while the thicker parts of the limestone should be much less altered in both respects; but this is the opposite of what

obtains; and so any explanation which requires that the agent of change should act from *without inwards*, does not suffice.

The whole facts of the case seem to point to an action taking place from *within outwards*. This view, at least, would seem to account for there being a greater change where the stratum is thickest;—the greater the mass, the greater must be the amount of action, if that action proceed from within.

But what action, physical or chemical, can be conceived to take place within, or emanate from a sedimented, amorphous, organic limestone, which could credit it with being at one and the same time the agent of its own metamorphosis into its crystalline allomorph,—of augmenting the metamorphosis of a rock in its immediate neighbourhood,—and of stimulating to the chemical union of the material of its own mass with the constituents of that rock?

Among the physical agencies which induce a change from the amorphous or colloidal to the structural or crystalloidal condition, we find *plication* and *heat*. Sir James Hall's experiments have shown that direct heat under pressure will change limestone into marble or calcite; and *plication*, in the very act of transforming a colloid into a crystalloid, does so at the cost, so to speak, of an elimination of heat from the substance so plicated. If we melt lead and pour it out on a flat stone, it assumes upon cooling the structureless, amorphous form, with rounded colloidal outline. If, after cooling, it is bent in the hand, it gives out heat, becomes crystalline in structure, gradually loses its pliability, and assumes the brittleness inseparable from the crystalloidal state. The same holds for iron, and for all metals capable of assuming the colloidal state; bend or beat them, they give out heat, becoming crystalline and brittle in so doing.

The heat here eliminated is doubtless partially the representative of arrested motion; but it is probably *chiefly* an outcome of the change from the colloidal to the crystalloidal condition; the agent of the elimination was the plication to which the substance was subjected, which plication was at the same time the immediate agent of the physical transformation.

I would venture to predict that it will come to be found that *the specific heat of substances in their colloidal state is always greater than that of their crystalloidal.*

I am not aware that any researches have been made specially to determine this point; or even that the attention of physicists has been directed to it; but the following table, which embodies all that I have been able to find, seems clearly to bear out such a view:—

COLLOID.		CRYSTALLOID.	
Water	1·	Ice	·72
Lamp Black	·26	Graphite	·201
		Diamond	·174
Limestone and Chalk	·264	Calcite and Marble	·201
Chalcedony	·195	Quartz	·179
Titanic Acid (artificial)	·172	Rutile	·163
Peroxide of Iron (artificial)	·176	Hematite	·166

Should it prove to be the case that the amorphous form has a specific heat always exceeding that of the crystalline, a step probably will be gained in the explanation of metamorphism generally; it may at least be held that the high specific heat of limestone, and the much lower heat of calcite or granular marble, explains the local metamorphism which we are now considering; as the plication, crushing, and folding of the strata *expressed, or extricated as heat of active energy* the difference in the amount of the specific heats of carbonate of lime in its two states,—the excess which is special to it in the colloidal. This expressed heat left only a residue, so to speak, sufficient for granular limestone; while it became the active agent in stimulating the chemical affinities existing between the limestone and the silica, alumina, and alkalies, of the gneissose matrix. It thus led directly to the formation of minerals, while it at the same time expedited or perfected a more thorough metamorphosis,—i.e., the assumption of a more perfectly-developed crystalline structure, in the previously only partially metamorphosed rock.

The assumption of a definite crystalline structure,—a character or property directly attached to a definite chemical composition,—must of necessity extrude from the resultant calcite the phosphate of lime, and fluoride of calcium, which limestones contain uniformly distributed throughout their mass. *Apatite* and *Fluorspar* are accordingly among the crystallized minerals found imbedded in the saccharoid "primary" limestones.

Whether the extruded heat can actually *fuse* the residual calcite may possibly yet be ascertained by direct experiment; but it would seem to be almost a necessary deduction that no mineral could be formed by such an action possessed of, or requiring a specific heat greater than that of the original source of the expressed heat.

It must be borne in mind that chemical elements do not alone go to the formation of any substance;—a due amount of certain physical agencies is the special portion of each, lodging, as it were, in their pores as resting places. Of the chemical ingredients, one alone may suffice; of the physical agencies, among which heat, phosphorescence, and magnetism, may be said to be those most germane to minerals,—

heat is the only one which is never absent. Chemical affinity then can only *predispose* to the union of the constituents which go to form the substance, for something more is requisite before the formation can be accomplished,—before the substance can, so to speak, assume an independent existence,—namely, the supply of the heat special to it,—to the perfect putting together of the whole as a mineral species.

It has, however, to be admitted that we are unable positively to affirm that the expressed heat may not be so concentrated in the spots where the chemical action is operating, as to afford any specific heat required.

Two arguments against such a view may, however, be adduced.

The first.—That the heat extricated throughout the general mass, would not readily be localised, or carried specially to any point in so badly conducting a substance as granular limestone or marble; more probably would it accumulate within the limestone itself, even to the point of its fusion;—and indeed the occurrence of porphyritically disposed crystals of quartz, with rounded angles, throughout the general mass of some marbles, (e.g. Ledbeg, Sutherland,) would seem to indicate actual fusion.

The second.—That it has not yet been shown that there is the necessity for such concentration.

The high specific heat of the matrix is, in the present case at least, amply sufficient; no one of the minerals found in the above localities possessing so large an amount of heat as ·264,—that of limestone.

That of the following is known:—

Fluor	·19
Apatite	·17
Tetrahedrite	·192
Actinolite	·204
Augite	·195
Diopside	·19
Pyrrhotite	·16
Molybdenite	·102

It is a somewhat significant fact that *limestone has a specific heat superior to that of any other rock mass;* we speak of mollusks and crustaceans as "cold blooded,"—though it is believed that they have a temperature somewhat higher than that of the medium in which they live;—but the calcareous matter which they have secreted from solution in that medium, for the defence of their soft parts, is deposited and arranged with an organic and non-crystalline structure, and consequently has had conferred upon it the high specific heat of the amorphous state; and so the long buried skeletons of these

rganisms are abiding store-houses of heat, until called upon to yield p their surplus store, and thus become the active agents of future hange.

I have here, as an indirect corroboration of certain of my views, to irect marked attention to the following observations on the circum-ances which were conceived by the writers to be capable of accounting or the markedly crystalline texture and high metamorphism of the ock which occurs in Glen Logan in Rosshire.*

Mr. Hudleston speaks of "the complex dislocations of the gion."

Nicol says that the rock "becomes serpentinous *where in contact with e limestone.*" Elsewhere he writes—"all along this line the rocks are oken by faults—some longitudinal, some transverse—with large agments, which have slipped down into the yawning chasms that ened into the vast rock, rent asunder as it rose. But there is no ason to regard this as the result of a solitary convulsion. Rather as ture's analogy would teach, that the arch was often forced up and actured,—often gave way, sank down and became welded anew by tense heat. For long ages the Titanic conflict may have gone on. it then wonderful that along this line the strata should be *crushed, ntorted*, thrown into apparently discordant position. That masses of e age should be brought into contact with masses of another: that edges of the higher limestone, or quartzite, should lie alongside or en lower down than the once deeper-seated sandstones or gneiss."

Professor Geikie writes—* * *"seem to us to prove it to be in ality a highly metamorphous band of felspathic grit,—*the superior gree of metamorphism being due to the existence of the limestone*, and ssibly also to the larger amount of felspar in the original rock."

Also — "the metamorphism *which is often most intense in the presence a limestone* is conspicuous here."

Mr. Hudleston writes that it "gives the idea of an old gneiss rtly *invaded by extravasated matter.*"

Professor Bonney speaks of a rock "which exhibits *a very marked gmental structure*, which he strongly suspected to be due to *crushing situ.* That not only the rock itself, but the *limestone* in contact th it appeared to be crushed.

Here it will be remarked that all the observers have noticed,—first, very unusual amount of crushing and fracturing,—second, an due amount of a change rarely referred in great part to increase temperature. This change has by each and all been assigned

* The italics throughout are the present writer's.

to the presence of limestone,—while one, apparently from his finding that the felspar of the rock contains lime, says that it gives the idea of being partly *invaded* by extravasated matter.

No one of these writers has, however, attempted to account either for this evolution of an excess of heat, or shown how the presence of limestone came to affect the rock,—or how the rock came to be affected by the excess of heat, in presence of the limestone.

According to the view of the writer, during this crushing and rending, the organic and colloidal limestone, if it became crystalline, must have given out much extra heat;—and in those localities where the greatest amount of this crushing turmoil was going on, the limestone might even come to play its usual part of acting as a flux,—rendering some portions of the rock so pasty, that they were forced into the gaping rents;—"invading" and altering the felspar of other portions; and being in some localities, itself so totally absorbed through combination, that occasionally,—as it is put by Murchison,—the absorbing rock "occupies the place of the limestone."

If the above be a philosophic rendering, then, inasmuch as it has lately been seen to be necessary to discriminate between *injected* rocks, and *eruptive* rocks, so now will it be necessary to find a place and furnish a name, for those which, in the presence of limestone, have been rendered pasty, or perchance semifluid, by crushing *in situ*.

I shall have to adduce, in future numbers, many localities where the more correctly termed "diallagic rocks" of Scotland, generally if not always associated with limestone,—show themselves to have been originally sedimentary deposits, which have been metamorphosed *in situ*, and that to such an extent that they were certainly softened in their own mass,—assuming *then* that structure which has led to their having been regarded as injected,—sometimes either involving fragments of other rocks, or apparently throwing out "veins."

It was with feelings of no ordinary gratification that I have lately read a paper by Dana, published in the American Journal of Science, for September, 1880, upon "The geological relation of the limestone beds of West Chester Co., New York,"

It is now five years since, in an address, delivered to the Mineralogical Society, in Glasgow, I endeavoured to show how a rock might be rendered plastic if not even fused *in situ* by the heat eliminated during its folding and crushing. Without assigning any of the heat so evolved to precisely the same cause as I did, Professor Dana clearly shows that a certain class of rocks, of diallagic, hypersthenic, and dioritic type, have been so metamorphosed *in situ* through crushing and folding, that they have become fluent to the extent of *involving portions of other rocks* in their mass, and of having been *forced into the fissures* of these rocks.

So important are the views and illustrations of this eminent geologist, and so immediately applicable to the circumstances of many of the diallage and limestone localities in Scotland, that no apology is needed in quoting what follows.

"The examples of what appear to be veins or dikes are also numerous. * * *

Some, if not all, of such veins must, therefore, be true veins or dikes; and are evidence as to the former fused or plastic condition of the material, and its injection into fissures. Veins formed in this way are not veins of infiltration or segregation; that is, they are not due to the filling of fissures by material supplied slowly in solution or vapour; for no difference in coarseness of texture or structure exists between the rock constituting them and that of the massive rock elsewhere; they are just such as have been made by simple injection. There are also peculiarities in the exterior of inclusions, and in the walls of veins or dikes, in some cases, which favour the idea of fusion. And in other cases, the limestone is impregnated with the hornblendic or augitic material in irregular lines or bands. Still more positive evidence, if possible, of fusion are shown at the junction of the schists of Cruger's Point with the soda-granite, where the schist itself bears evidence of partial fusion, and exhibits other contact phenomena.

The proof of the crystallization of the rocks from a more or less perfect state of fusion or plasticity is thus complete. But admitting fusion or a plastic condition, the question still remains:—

Were these once-fused rocks fused approximately *in situ*; that is, where, or near where, they now lie; or were they erupted through fissures from great depths below? that is, using Dr. Hunt's terms, are they *indigenous*, or are they *exotic*?

If they were fused where approximately they now lie, that fusion must have come from accessions of heat, and such accessions may have resulted from the movement and friction connected with an upturning of the rocks; and it may have been one of the results, in that region, of metamorphic action at an epoch of general metamorphism, and if so, at the very time that these rocks became fused or plastic through the process, other rocks of the region, owing to less extreme metamorphic action, or to less fusibility, may have been left with their bedding unobliterated; just as much granite in New England and other countries received its crystalline condition in the same process, and at the same time with the associated schistose rocks,—the gneisses, mica schists, etc. * * *

As has often happened in the case of granitic rocks, and even granular limestone, the fused or plastic material, under the pressure attending the subterranean movement, would have entered and filled all fissures that might have been opened to it, and so have made veins or dikes having the sizes of the fissures, were they large or small, and possessing also a uniformity of grain like that of ordinary erupted rocks.

Again, whatever the process of ejection, fragments, large or small, of any rocks adjoining such fissures might have become included in the fusal or plastic material. In the writer's Manual of Geology (1880), veins of this kind are called *veins of plastic injection*, an abbreviation of the full statement that they were made by the injection of material rendered plastic or fused during a process of metamorphism. * *

The results of fusion of sedimentary beds under metamorphic action may have distinguishing peculiarities. *First*:—

The kinds of rocks so resulting are likely to vary greatly, at comparatively short intervals, because sedimentary beds often vary thus. They should not have that uniformity for scores or hundreds of square miles, which often characterizes ejections that have come up from the regions beneath the supercrust. Sediments, and therefore sedimentary deposits, are liable to frequent and sudden changes as to material, which igneous outflows cannot imitate. *Secondly*: the rocks are likely to have no columnar (basaltic) structure; because the fractures to be filled in such cases are fractures in rocks which are participating in the movement, and which, therefore, are heated rocks, and not cold. * * *

The facts with reference to inclusions, and all contact phenomena bear directly, as will appear, upon the question as to any stratigraphical relation in the Cortland rocks to the limestones; and they are, therefore, here taken from the vicinity of particular limestone areas. * * *

A natural inference from the series of facts presented in this section would be that the heat was a consequence in part, if not chiefly, of the movement and friction attending the flexing; and that consequently there was produced a more and more yielding condition in the material of the schist as the region of complete fusion was approached, and at the junction, perhaps, a fusing and obliteration of portions of some

layers of the schist; *but are not these flexed portions of beds, fragments that were broken off and carried up by the fused or plastic material as it rose from the depths below?* They lie so conformably to the flexures of the schist as to suggest *a negative reply* to this query. * * *

Since it is obviously impossible that the inclusions taken in and carried up by rock erupted through deep fissures should be beds of schist 100 to 200 feet long, and a series of such beds separated by the fused rock retaining together their parallel position, we have to admit that these indications of bedding are of *unobliterated* bedding. The rest of the upturned strata were fused or at least softened; these portions of beds were not fused, though flexed and variously displaced.

There is reason for the resistance to fusion in the mineral nature of the beds; for quartz, staurolite, fibrolite, magnetite, are infusible minerals; muscovite and biotite are but slightly fusible on thin edges; and orthoclase fuses with great difficulty, much greater than the other felspars, oligoclase, labradorite and albite.

Thus the study of the phenomena of contact becomes in this region a study of "inclusions;" and the larger of the inclusions turn out to be beds of schist, conformable to the schist. We seem to be thus forced to the conclusion that *the soda-granite* and the included *diorite* were once *parts of the same sedimentary strata with the schist*, and that all, with the Cruger limestone, were once a continuous stratified formation; and that the plasticity given to the granite-making or diorite-making portions, because of the heat, occasioned the exceptional geological features of the region. * *

All the material is very pyrrhotitic. * * *

The impregnation of the limestone along the junctions with pyroxenic or hornblendic material, sometimes in minute crystals, looks as if it may have been in part at least a result of mixture attending original deposition. This view is also sustained by the occurrence in the limestone near the schist, 1000 yards from the point, of coarse spots of pyroxene with mica and chlorite rudely in layers, which must be due to the original deposition of impurity, and metamorphic action. * *

The plasticity occasioned in part of the latter, (augitic and hornblendic rock) during the progress of the metamorphism, accounts for all that looks like eruptive phenomena even to the broken feldspar grains found in a slice of the pyroxenyte of one of the so-called veins. There is nowhere evidence of injection into or through cold rocks. * *

And, among so extensive masses of rocks that *became plastic or fused in the era of upturning*, this abnormal position of included strata is not strange. * * *

This ledge, although made up mainly of massive norite and augite-norite, bears thus positive evidence of its having once had bedding throughout, and affords thereby a demonstration that its noryte is of metamorphic origin, and that the associated beds comprised also the limestone of the region.

The whole facts appear to sustain fully the following conclusions:

(1.) These rocks, although they include soda-granite, norite, augite-norite, diorite, hornblendite, pyroxenite, and chrysolitic kinds, are *not* independent igneous rocks erupted from great deposits. However complete their former state of fusion or plasticity may have been they are *metamorphic* in origin. On the view reached, it follows that the limestones, schists, and other rocks of the Cortland region, originally constituted together one series of horizontal strata. They underwent an upturning through subterranean movements, and in the course of it, they became metamorphosed; part into mica schist and gneiss, part, by loss of bedding, into the massive rocks. The number of these rocks does not imply widely different ingredients in the original strata. For hornblendite and pyroxenite have the same chemical constitution; the chrysolitic rocks contain no ingredient not in them also, and are peculiar mainly in their less proportion of silica. Moreover, the diorite, norite, and augite-norite are like in containing the same bases in nearly the same proportions. The soda-granite differs in chemical constituents only through its mica, which indicates the presence of potash.

The title of this paper might, therefore, well have been:—

Soda-granite, norite, diorite, hornblendite, pyroxenite, and various chrysolitic rocks made through metamorphic agencies in one metamorphic process.

The geologist will nowhere on the continent find a more instructive spot for a day's walk than in the western portion of the Cortland region.

He may see enough to satisfy himself that, although there has been fusion and some eruption, it was *not* eruption from the earth's deeper recesses, like that which brought up trap (dolerite) through a series of great fissures, for a thousand miles along the eastern Atlantic border, from the Carolinas to Nova Scotia, all of it rock of one kind essentially; but eruption from less depths, not greater than the lower limits of a series of formations that were subjected together to foldings, fractures, and metamorphic change, *and mostly far short of this.*

While the Shinness locality by no means, according to my own observation, affords the best illustrations of the facts upon which the above speculation is founded, still it is one which aids in supplying direct evidence.

It is observable, as we approach the neighbourhood, that the ordinary muscovitic-schists and lepidomelane-gneiss of Achadhaphriz become more and more hornblendic; while a bed of hornblende rock overlies the lime itself. Hence it would appear as if some thinner beds of limestone, or at least more calcareous strata, had supplied the lime of the replacing hornblende.

It is next notable that the rock adjacent to the lime has suffered, in a markedly higher metamorphism; for *determinate crystals*, and imbedded groups of crystals of *orthoclase*, *hornblende*, and *lepidomelane*, are to be obtained from it.

A kind of *welding* of the rock with the lime stratum, is next observable; and this is accomplished by the occurrence of a linking zone *which consists of those minerals which are formed* (*or could be formed*) *by the union of the two.* This zone is here the chief site of the mineral species, comparatively few occurring *in the mass* of the lime itself.

If such occurrence,—*i.e.*, central to the lime itself,—depends upon the separatory crystallization of the several chemical ingredients, and the consequent clarification of the calcarious bed, it is evident that a deposit of pure carbonate of lime could yield only *calcite* crystals.

A dolomite would probably yield crystals of *magnesite* and of *pearlspar* in addition thereto: a silicious limestone would, in addition, supply *Wollastonite** and *malacolite*,—according to the amount of silica present; while a fossiliferous limestone should likewise supply *apatite*, *fluorspar*, and, in the *first* stages of its metamorphism, *pyrite.*

An impure or argillaceous limestone would yield *garnet* or *idocrase*, or a *felspar*:—the latter would be less likely to occur in dolomitic limestone, argillaceous varieties of which would contain *magnesian* garnets.

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*Bischof writes:—"The adherents of the plutonic theory regard granular limestone as sedimentary limestone that has been altered by volcanic action; and they would, therefore, suppose Wollastonite to have originated in the same way, more especially as it occurs in the masses erupted by Vesuvius. It is remarkable that Wollastonite occurs only in granular limestone; not in sedimentary limestone, where the conditions for its formation obtain equally." *i.e.*, they obtain equally according to *Neptunian* views.

Much more information may be expected to be derived from the minerals which occur in the limestone itself, than from the mere contact-products. If, however, the stratum be not a single thick bed, but, is subdivided by laminæ of what had been muddy silts, the amount of information is minimised.

We are in some localities forced to the conclusion that the marble has been *plastic, if not fluent.* At Glengairn in Aberdeenshire, and Allt Gonolan in Invernesshire, it passes round and cements fragments of inclosed rock, not at all after the manner of a breccia cemented by igneously-intruded calcareous matter.* In the latter case, the size of the rudely crystalline calcareous concretions, depends upon the size of the vein or fissure, from either side of which they grow, sometimes in successive bands or layers with varying size of granules. But the granular structure of the marble, at the above localities, passes into the cementing portions *unchanged in size and appearance;* and the plug is of uniform grain throughout.

Another fact which goes a certain length to vouch for much of the heat having emanated *from the limestone*, is the fact of the invariable occurrence of the *augitic* type of mineral within it.† The assumption of, or at least the fact of the occurrence of *hornblende* in the

* I shall afterwards adduce facts which almost incontestably show that many so-called "igneous rocks" in Scotland owed that plasticity which enabled them to be "injected" into fissures of moderate size, to an exalted metamorphism in situ; the *requisite* heat being due to crushing and folding. At present I confine myself to an *augmentation* of that heat, *consequent upon the presence of lime.*

† So great and so *invariable* is the occurrence of one or other form of *augite* in connection with the "primary limestone" throughout the whole of the Highlands of Scotland, that it was with no little wonder that the writer observed the following statement—in a critical review of a work by Messrs. King and Rowney, in which these authors are being taken severely to task for postulating points in dispute. "Augite and hypersthene are placed among mineral species 'common to ordinary metamorphics.' The authors are surely aware that at any rate normal augite cannot be called common in metamorphic rocks." While prepared to admit that the augite present here in the outer-zone of the contact-band, may, if it shews a uralitic structure, possibly result from a transmutation of the adjacent hornblende, yet there are many localities in which such augite is seen, where there is no hornblende in the neighbouring gneiss; while the mode of occurrence and the amount of the sahlite and malacolite in the limestone, is such as to entitle us to say that it becomes the mineral *typical* of *this* metamorphic rock;—while in some localities *it actually forms its mass*, and this it does to such an extent that the quantity of *augite* in one form or another, cannot, in the upper-gneiss of Scotland, be much smaller than that of the *hornblende.*

Very possibly the above writer will hold primary limestone to be not an "ordinary metamorphic"; and, as he seems to regard augite as being typical of rocks which have at least been *subjected* to a high heat, we should expect him to agree more or less with our views relating to this limestone; his adhesion to our views would bring satisfaction, if we did not observe that the microscope seems to be by him regarded as an *instrument of precision*, instead of being at present a mere adjunct—however valuable,—in lithology.

adjacent strata has been noticed. In what may called the contact-zone this gives place to the augitic type of the mineral; though *there* an actynolitic, or perhaps it should be said a *zoizitic* form of hornblende occasionally occurs: but, as we pass from the outer sides of the zone *sahlite* makes its appearance, while the central parts of the limestone contain *malacolite* alone. Indeed, as has been noted, that mineral frequently occurs in such amount that but little lime remains.

The last fact to be noted is that there has been, in every case where the lime is highly granular, *a strong reducing action* of some kind. Flakes of *graphite* stud these beds, frequently throughout, (a small vein of it was found at Urquhart); and the *pyrite* of the little-altered limestone, *is invariably pyrrhotite in the marbles.*

I am not prepared in the present state of our knowledge to consider how the carbonic acid was reduced to graphite, or whether any residual organic carbon was crystallised into it. The occurrence of the lower sulphuret of iron (*pyrrhotite* is $Fe_7 S_8$,—*pyrite* $Fe S_2$) is not, in the presence of the formation of the graphite, so difficult of explanation. Both Berzelius and Rammelsberg found that $Fe_7 S_8$ was the direct result of the action of heat upon $Fe S_2$. The occurrence of a spring strongly charged with sulphuretted hydrogen, about 200 yards north of the line, also aids in the explanation in this case; for that gas is the product of the action of even weak acids (? carbonic) on pyrite.

The facts, then, which are to be observed regarding the granular limestones are,—a higher degree of metamorphism, as evidenced by a more dominant exercise of the crystalline force in the adjacent strata;—the occurrence of a *contact-zone*, rich in such minerals as would result from the combination of the siliceous rock with the calcareous seam;—the segregation apart in that seam itself of its own specially constituent parts—and the occurrence therein of reduction products.

The circumstances which are favourable to a dominant exercise of the crystalline force, in the direction of forming crystals larger than the normal, have no power to limit it to the direction alone of inducing merely a state of more ample aggregation. Such dominant exercise must also have given rise to that which is self-evidently a preliminary to the formation of more amply developed crystallization, —namely the drawing together,—the local segregation of the material, through the accretion of which such crystals are built up.

From this it results, that there are drawn to the situation where the crystalline action is operating in full force, certain at least of those

substances which occur throughout the general mass of the siliceous rock in quantities so minute as to be there incapable of recognition, even with the aid of the microscope. These are now presented to us definitely crystallised from a calcareous flux; and convey all the precise information which a special crystalline form affords. This often more than compensates for the minuteness of their bulk.

Such substances are *sphene, zircon, Allanite, and molybdenite.*

The place of the occurrence of these is significant.

A few crystals, say of sphene, are found in small open cavities, some inches distant from the junction of the siliceous rock with the limestone;—a very few imbedded in the rock near these, but these are distorted through surface contact; but by much the largest number line the surface of the rock where it is in contact with the limestone, and are only seen when the latter is dissolved off by acid.

They are then found to have grown out of the rock surface; and those portions which had been imbedded in the limestone are *perfectly formed crystals*, the perfection of the faces being in no way detracted from by the effect of any crystalline effort on the part of the limestone.

How comes it that the crystals which have formed here are as perfect as those which have formed in the *vacuous* cavities;—and why did they form there at all? *Only because there was there as perfect freedom of motion for the molecules to arrange themselves, as there was in the cavities*,—with greater space also for that arrangement. A fluent medium,—a readily displaceable fluid—must have filled both spaces. Air filled the one; it will not be suggested that the limestone was an after injection, therefore the limestone which filled the other *must have been fluent at the time when the sphenes pushed its particles aside in order to assume their own individual form.*

Nay more, it was no mere hasty arrangement of molecules, in some one of the simplest forms of the mineral;—the forms here occurring are the most complex in the country,—several are twins with many faces. There was time, so to speak, for the deliberation of choice, and the exercise of the highest and most intricate whimsicalities of the force of crystallization.*

When we take into consideration the whole of the granular limestones of Scotland, *andesine, Biotite and sphene* are found to be characteristic of the contact-zone;—*malacolite, pyrrhotite*, and *apatite*

* I do not here, for want of sufficient data, enter into a consideration of the *modifications* produced by the presence of certain media,—calcite, however, does not generally induce complex modifications.

equally so of the limestone itself;—while *orthoclase* and *actynolite* appear in the neighbouring rocks.

The occurrence of minerals at this—one of the richest limestone localities in Scotland—was first noted by Dr. Joass. Through the courteous assistance of His Grace the Duke of Sutherland, Mr. Dudgeon and the writer were enabled to make a thorough examination of it, at the time when it was being worked. The following are the results.

There are two beds of limestone, each about seven feet in thickness ; they are first seen upon the shore of the lake, on the west side of the promontory of Shinness ; they extend for about 400 yards as limestone ; and the calcareous compounds which they form by their union with the gneissic rock, continue for about an equal distance to the eastward, disclosing their presence in a series of green knolls.

The dip of the beds is to the E.N.E., at an angle of about 35°, and this dip is maintained by the overlying rock nearly to Lairg,—where syenite comes in,—and in a northward direction as far at least as to the road which passes to the Crask.

Both beds are similar; being large granular, with at times very little cohesion of the granules. The upper is the coarser in structure, the granules being of the size of peas. This bed is sometimes very strikingly diversified by red bands of a high colour and a parallel disposition.

In its general mass the limestone is very pure, the minerals occurring only towards its sides, and chiefly the upper side. The intermediate zone of rock is about a yard in thickness.

Dr. Thomas Anderson has given the following analyses of the limestone.

	TOP.	MIDDLE.	BOTTOM
Carbonate of Lime	84·11	93·70	89·95
Carbonate of Magnesia	7·45	3·49	4·93
Ferric Oxide and Alumina	·76	·28	·46
Silica and Insoluble	7·42	2·52	4·77
	99·74	99·99	100·11

In the gneiss which is in contact with the limestone, only two minerals occur of purity and size of crystals fitted for analysis. These are a dark mica, and a pale brownish white *orthoclase.*

A qualitative analysis showed the mica to be *lepidomelane.* It was in plates about three-fourths of an inch in size.

The felspar was in interpenetrating crystals of nearly uniform size ; its specific gravity is 2·56. As it occurred within twenty or thirty feet

of the limestone, it was analysed to ascertain if the quantity of lime was in excess of that normal to the mineral.

It yielded—

Silica	64·23
Alumina	18·682
Ferric Oxide	1·318
Lime	·69
Magnesia	·384
Potash	12·377
Soda	1·256
Water	·705
	99·642 (H.)

It can hardly be said that there is here any marked increase in the normal amount of lime.

In the contact zone there was found the following large assemblage of minerals,—

Biotite, common.	*Apatite, rare.*
Actinolite, rare.	*Chlorite, rare.*
Augite, (Funkite).	*Asbestus, common.*
Pyrite, rare.	*Tremolite, rare.*
Sahlite, common.	*Steatite, rare.*
Andesine, rare.	*Talc, very rare.*
Sphene, scarce.	*Pyrrhotite, scarce.*
Molybdenite, very rare.	*Malacolite, common.*

These are arranged in the order of their occurrence from without inwards, in the rock.

A point of much interest here is the occurrence, so near to one another, of the three varieties of the one mineral,—the dark-green *Funkite*, the pale sap-green *sahlite*, and the milky *malacolite*. These in no way pass into one another,—they are perfectly different in appearance; occur invariably in different positions; and differ much in the size of their crystals.

Another point of note is the paragenetic occurrence of the *hornblendic* type of mineral; this also presents itself in three varieties, which do not shade into one another,—*actinolite, asbestus, tremolite*; these also differ entirely in appearance. It must be here noted, however, that I have offered no proof, analytic or otherwise, that the asbestus and tremolite are not of the augitic type of mineral.

The first mineral noted above is *Biotite*. This frequently forms a solid crust between the gneissic rock and the contact zone; this crust seems to consist of little more than a dense mass of minute flakes of the mineral.

Rarely it occurs in large rich-brown flakes in the chlorite, and more frequently in smaller ones of a light greyish-brown colour. The smaller crystals are superimposed upon one another, so as to have a foliaceous appearance; this variety also coats crystals of sahlite.

As the peculiar greasy lustre of these pale crystals gave some hope of their being *phlogopite*,—a mica which I have not yet found in Scotland,—they were analysed, and yielded

Silica	39·769
Alumina	16·676
Ferric Oxide	·653
Ferrous Oxide	6·73
Manganous Oxide	·615
Lime	2·196
Magnesia	20·923
Potash	6·5
Soda	·476
Water	5·398
	99·936 (H.)

being thus merely Biotite.

The specimens of *actinolite* were dark-green in colour, they were in interlacing imbedded crystals associated with *Funkite* and *Pyrite*. They were rare, and inferior as specimens. The *Funkite* was also in imbedded crystals of about an inch in length, by half that width; it was in four-sided crystals, but their terminations were obscured. Cubes of pyrite occurred along with these, and pyrrhotite in larger amount was also here associated. It was massive only.

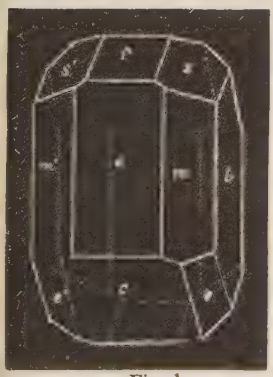


Fig. 1.

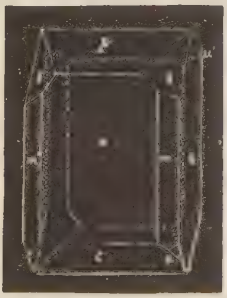


Fig. 2.

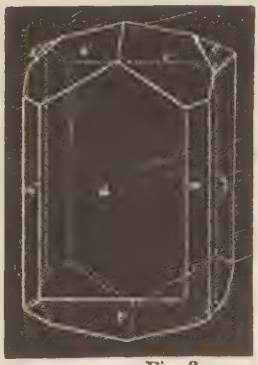
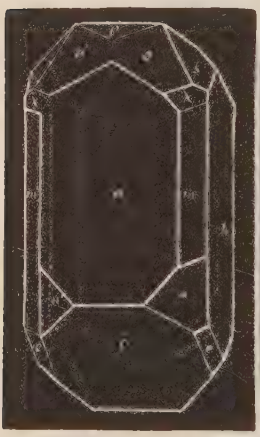
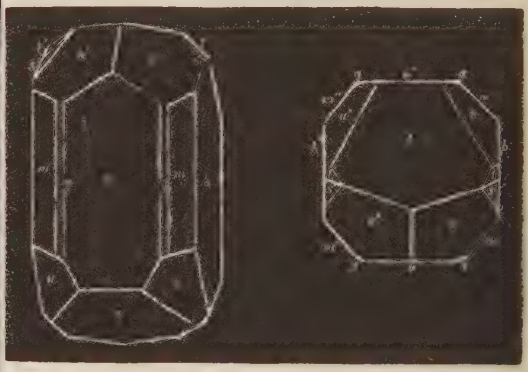


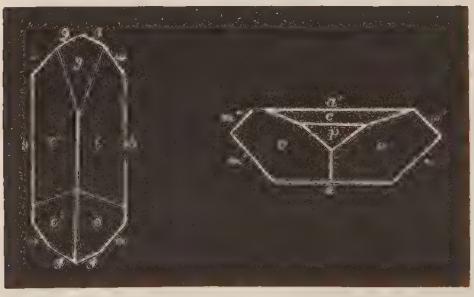
Fig. 3.

Sahlite occurs in great quantity generally in interlacing foliaceous crystals, but sometimes in flat crystals, imbedded partially in limestone; these are disposed one over the other, with half an inch of limestone

intervening: they are an inch in thickness by several inches in length and breadth. We were not so fortunate as to break up the masses of lime in such a way as to obtain the terminations of these large crystals; some, which were placed in acid in large mass, gave only rough terminations; but the surfaces of the large crystals were occasionally studded with small individuals, five forms of which are depicted. These crystals had a dull sap-green colour; but occasionally equally large crystals were of a fine grass-green.





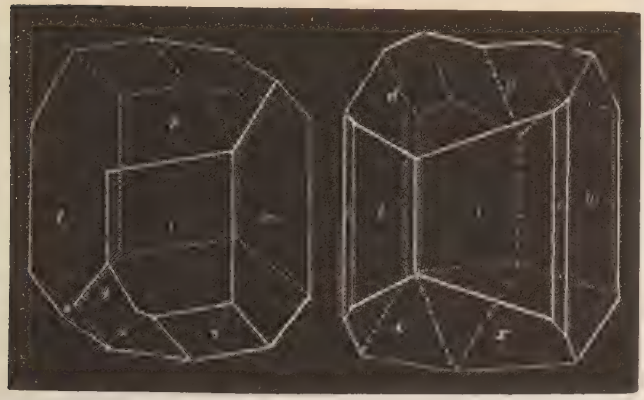


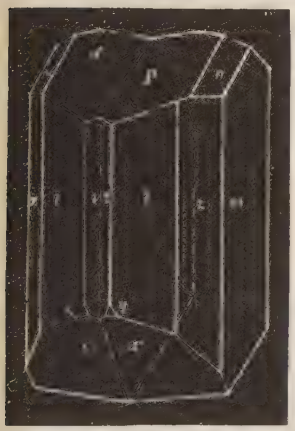
Occasionally the small crystals of sahlite have their faces so abnormally developed as to appear distorted, and to be with difficulty recognisable.

The summits of the two extreme forms of such are drawn in the same position.

Cavities of any notable size rarely occur in the massive lumps of the sahlite.

A very few of the larger of these contain a felspar, of which I had not enough for analysis. This, from a chemical determination of the felspar of the granular limestones in other parts of Scotland, where it invariably has proved to be *andesine*, I assign to that mineral.





I was able to draw three of the forms in which this felspar occurs—one simple crystal, and two twins; these forms would equally well accord with the mineral being *albite*, but, for the above reason, and another immediately to be stated, I prefer to consider it *andesine*.

The crystals have the colour and lustre of bleached wax, or cold suet; they are of the size of peas or small bullets; they show striation occasionally.

A point of very great interest connected with them is this;—a specimen of sahlite which had a cavity plugged with calcite, happened to have been placed in acid stronger than that which was usually employed for the removal of the lime carbonate. When the action was at an end, it was found that the cavity contained several of the felspar crystals, and all had their composite striation-structure disclosed through *the alternate layers* having been dissolved almost entirely away. A series of thin plates remained; these also had been slightly acted upon.

So much had the plates been dissolved away, that the crystals upon another specimen were tried gently with a knife, and touched with acid to see whether it was not possible (however improbable), that the alternate layers were calcite. This they were found not to be.

Here is a most valuable piece of information.

It shows firstly that the crystals could not be *albite*; for *it* is insoluble in *strong* acid, even when in powder. The acid used was about one of chlorhydric acid to four of water.

It shows in the second place, that sometimes striated crystals of felspar are *made up of alternate plates of two homœomorphous felspars.* In this case one was soluble in weak acid, while the other was not.

The question now presents itself. Supposing it to be *andesine* in composition, is that composition, and is the crystal-fabric, made up of alternate and reversed layers of *anorthite*, which is soluble in acid,—and of *albite*, which is not?

Unfortunately I have not enough of these crystals to decide this by the aid of chemistry. They differ in appearance from such of the limestone andesines as I have analysed;—first in their being regularly and perfectly crystallised, and secondly in their waxy translucency; those from other localities being milky and opaque. There are however trifling distinctions.*

The *Sphenes* of Shinness are certainly the finest in Britain, at least as regards their form. One specimen also was the largest crystal which I have seen from Scotland. This was a crystal of simple form, which we found exposed on the roadside. As this crystal seemed to be somewhat loose in its matrix of sahlite, it was measured, and found to be two inches in length, by one in width; it was of a pale-yellow colour. In "dressing" the specimen the crystals started in fragments from the stone. Its specific gravity was 3·617.

The fragments were analysed and yielded—

Silica	34·666
Titanic Acid	35·464
Alumina..	2·897
Ferric Oxide..	tr.
Manganous Oxide	·499
Lime	26·853
Magnesia	tr.
	100·378 (H.)

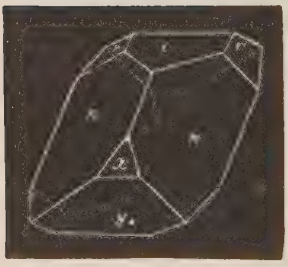


Fig. 1.

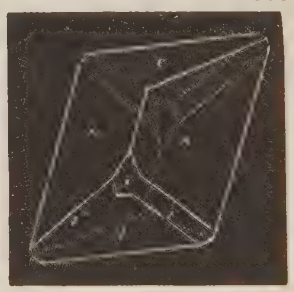


Fig. 2.

In general however, the sphenes are not half the size of peas. With the exception of the before-mentioned crystal, they are all of a dark hair-brown colour.

* I have since treated the andesine from Urquhart and that from Dalnein—both of which analysis has proved to be andesine, and both of which are striated—with acid of one to four of water, and also with strong acid, without observing any effect.

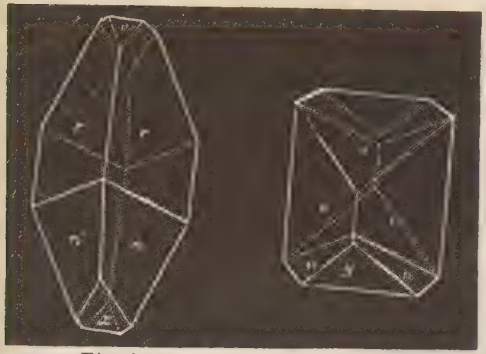


Fig. 4. *Fig.* 3.

They are seldom of simple form. Figures 1 and 2 show the simplest.

A difference of dominance in the faces *n* and *v* occasions the diversity of appearance shown in the figures 3 and 4, which are nearly the same form.

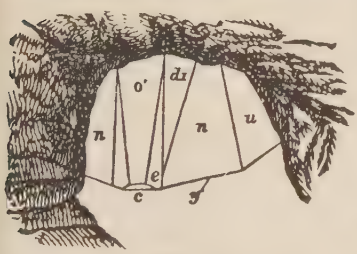


Fig. 5.

In the very complex form, figure 5, the crystals are so imbedded in the matrix that some of the faces have been somewhat conjecturally lettered.

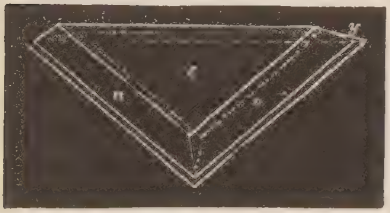


Fig. 1.

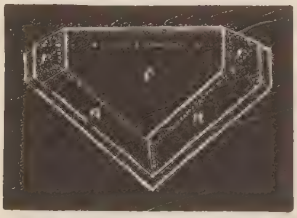


Fig. 2.

In the twin forms,—which are nearly as frequent as are the simple

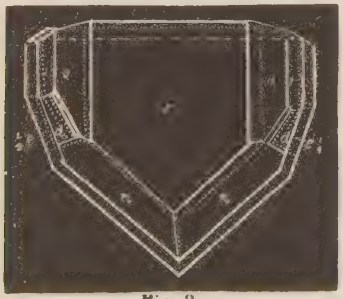


Fig. 3.

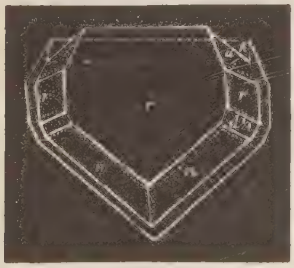


Fig. 4.

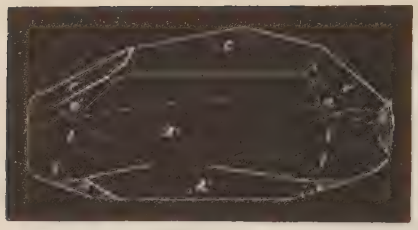


Fig. 5.

Fig. 6.

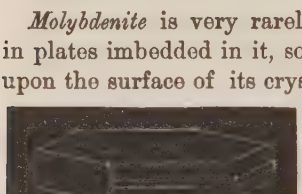
crystals,—the face which truncates the angles of *n c r*, and which is seen in three of the crystals, would appear to be new. It is somewhat too rounded for measurement. Figures 5 and 6 are placed in an inverted position, in order to show a larger number of faces.*

The dark-brown sphenes yielded to analysis:—

Silica	36·789
Titanic Acid	35·393
Alumina	2·208
Ferric Oxide..	·284
Manganous Oxide	·299
Lime	25·403
	100·376 (H.)

The cavities which held these sometimes also contained crystals of *Biotite*

Molybdenite is very rarely associated with the sahlite. Sometimes in plates imbedded in it, sometimes in rosette crystallizations perched upon the surface of its crystals.



The annexed form was seen; this, if correctly drawn, would leave some doubt as to its being hexagonal. The crystal however was extremely minute.

The *Apatite* which occurs here is also imbedded in sahlite; it is in fissured lumps of a pale asparagus green colour.

The only specimens I have seen of *asbestus* were sent me by Dr. Joass, but they must at one time have been found in great quantity, for some of it performed the function of "packing" to the other minerals sent me by him.

It was in fibres of several inches in length of a greyish straw colour and a high lustre. It was hard, rigid, and rough, though in

* In figure 6 the faces marked *o* should be *d*, in the *lower* half.

other respects very similar to the valuable variety from Balta; it contained a little chlorite among its fibres.

It yielded—

Silica	56·864
Alumina	·232
Ferric Oxide	·484
Ferrous Oxide	2·124
Manganous Oxide	·23
Lime	12·535
Magnesia	23·923
Potash	·439
Soda	·538
Water	2·525
	99·866 (H.)

Dr. Joass also sent me long hatchet-shaped masses of closely-packed parallel fibres of a pale-green colour; these were somewhat amianthiform.

To Dr. Joass I am also indebted for a specimen of *tremolite*, which not only surpasses in beauty anything of the kind which I have seen from abroad, but which is one of the finest minerals ever found in Scotland. Nearly a foot in size in all directions, the mass is covered with parallel bundles of glancing fibres of the most delicate tenuity; these flash with a brilliant but chastened light, of more than silvery whiteness. No natural object devoid of colour could possibly be more beautiful. Its specific gravity is 2·964.

It yielded—

Silica	56·153
Alumina	·857
Ferric Oxide	1·617
Ferrous Oxide	·716
Manganous Oxide	·069
Lime	13·31
Magnesia	24·138
Potash	·441
Soda	·211
Water	2·5
	100·012 (H.)

It is not only possible, but very probable, from the small amount of alumina which replaces silica in these last two minerals, that they are both *augitic* minerals; the nature of their matrix also bears out such a view.

For the next two minerals also,—*steatite and talc*,—I am indebted to Dr. Joass; all of these occurred in a quarry which was exhausted

before my confrere, Mr. Dudgeon, and myself examined the stratum; it is well for the records of Sutherland science, that so keenly observant an eye had been there before us.

This steatite is peculiar; it occurred in rounded nodules,—from the size of a marble to that of a golf ball,—one side of which lay directly in the calcite. It was massive, but had an obscure laminated structure; the colour of it was that of cream, blotched with pale blue. It was hard, cutting like slate pencil; from its rough surfaces there rarely protruded small crystals of *talc*.

This steatite is aluminous, it yielded—

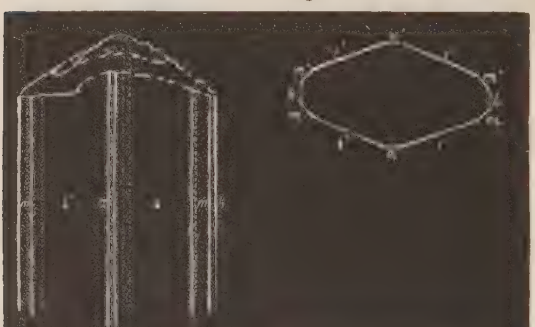
Silica	67·089
Alumina..	1·586
Ferrous Oxide	1·822
Magnesia	23·297
Water	6·048
	99·887 (H.)

Its specific gravity is 2·74.

Pyrrhotite occurs at this locality in perhaps smaller quantity than at any other of the primary limestone localities in Scotland. It is here generally associated with the darker varieties of augite, but seldom appears in the limestone, and scarcely ever sprinkled throughout it, in the manner usual to the mineral.

Indeed the same may be said of the last mineral I have to notice, viz. *malacolite*. The freedom of the general mass of this limestone from imbedded minerals does not give countenance to its having been a highly fossiliferous stratum; its purity indeed, entitles us to doubt its having been at all fossiliferous.

As the contact-zone merges into the limestone, *malacolite* of a dull yellow colour appears. It shows rarely the unterminated forms drawn. The variety of this mineral which is actually in contact with the limestone, or is imbedded in it, occurs not only in larger crystals, but in much larger quantity than at any other locality in Scotland.

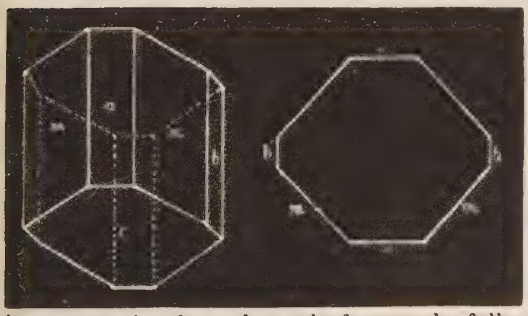


Though very seldom showing crystalline faces, being imbedded, it is here so pure in colour, so lustrous, and in such large masses, that this must be regarded as decidedly its best Scotch locality. Sometimes it occurs in distinct layers in the limestone.

Frequently it is found in widely radiating crystals; and single crystals a foot to sixteen inches in length, by an inch or two in breadth occur. These are frequently fissured transversely,—delicate amianthiform fibres of extreme tenuity and silky lustre, stretching across the gaps, sometimes a fourth of an inch in width, to connect the severed portions. These gaps are filled with transparent calcite.

The malacolite has a cleavage angle of 87° 5′, and a specific gravity of 3·149; it yielded—

Silica	53·062
Alumina	·193
Ferric Oxide	1·773
Ferrous Oxide	·47
Manganous Oxide	·153
Lime	23·626
Magnesia	19·295
Water	1·546
	100·118 (H.)



The only crystalline form I have seen is the simple one drawn.

The *c* cleavages of the malacolite and sahlite of Shinness, and indeed of the malacolite of Scotland generally is so eminent that the crystals, during extraction from the rock, frequently fall asunder along it. This is not admitted to be a cleavage face by Brooke and Miller, being regarded as merely a line of opposition of a plurality of crystals.

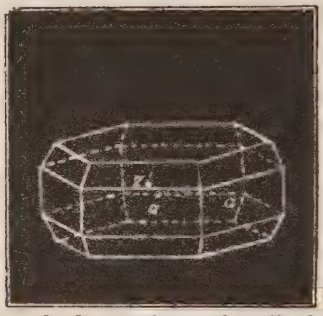
These *c* cleavages are here, and at several other localites in Scotland, evident to the sight by a parallel lineation of the mineral. In the more transparent of the Shinness specimens this lineation appears as narrow opaque white bands; in the sahlites generally, as in that of Tiree, as lines which are not only opaque, but which have a depth of colour which is invariably paler than that of the general mass of the crystal. This parallel lineation also constitutes the most characteristic microscopic feature of the stone; but the writer has one

specimen which with polarised light exhibits a singular oblique-angled and crossed tartan pattern.

Arskaig.—The same bed of limestone, thrown up by a fault, appears at this locality on the south shore of Loch Shin. It here lies between two cross faults.

It has been mostly wrought out, but is more feebly developed than at Shinness. *Malacolite*, *sahlite*, *actinolite*, and *pyrrhotite* were seen here. Doubtless if it were still wrought, other substances would be found.

The pyrrhotite was occasionally in well-defined small crystals.



These had sometimes a hemihedral habit,—the more largely-developed of the faces *a* being in that case striated.

Description of a Crystal of Euclase, belonging to my Collection.

By M. Guyot (de Grandmaison).

(*Read December 23rd*, 1880.)

THE crystal comes from the mining district of Boa Vista, near Villa Rica (Brazil), where the alluvial diamantiferous strata occur with chloritic schists. It exhibits great regularity in the disposition of its faces and in its physical characters.

Fig. 1.

Its total weight is 15·45 gm. Its dimensions are given by the scale shown on the woodcut (Fig. 1), which is of natural size. Its density is 3·087.

Colour, sea-green, like beryl; lustre, vitreous, nacreous on certain cleavage planes.

Fracture conchoidal, very fragile. Cleavage easy and perfect.

The prism is oblique rhombic, its angle 144° 37′; one termination is complete with numerous modifications, the other fractured, with traces of chlorite schist in the cracks.

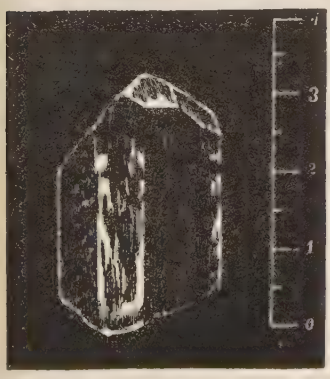


Fig. 2.

Strong double refraction, slight dispersion of the axes.

Inclined dispersion manifested by the unequal brilliancy of the colors in the two systems of rings.

Some of the faces of the vertical zone striated parallel to their mutual intersection, easily seen on the face to the right (Fig. 2).

Becomes electrical on the least friction, and even on simple pressure.

Note by J. H. Collins, F.G.S.

With this note M. Guyot has sent a series of photographs and a cast of the stone. The measurements which I have been able to obtain from this are, of course, not very accurate, but they show that the following planes are present.

a. 100. a narrow plane.
a'. $\bar{1}00$. a wide well-developed plane.
b. $0\bar{1}0$. apparently a large cleavage plane.
c. 001. doubtful whether present or not.
s. 110. a large well-developed plane.
s. $\bar{1}10$. a well-developed plane, but smaller than the last.
k. 210. a large well-developed plane.
k'. $\bar{2}10$. a narrow plane.
f. 131. a rather small plane.
f'. 131. a large plane.
f''. $\bar{1}\bar{3}1$. a very large plane.
r. 311. a small plane.
o. 121. a small narrow plane.
o'. $1\bar{2}1$. a small narrow plane.

The crystal appears to be a portion only of a still larger one—but it is evident that it was always hemihedrally developed. It is certainly one of the very finest specimens of Euclase which has ever been discovered, and M. Guyot authorises me to say that he will be at all times pleased to show it to his fellow-members.

Reviews and Notices.

MONETITE AND MONITE FROM THE ISLANDS MONETA AND MONA, W. I. (By C. A. SHEPARD, *Am. Journ. of Science*, May, 1882.)—*I. Monetite.*—The mineral from Moneta, which the author names monetite, occurs in a guano-formation, lining the walls of cavities, sometimes in isolated patches, half the size of one's hand. More rarely occurring in botryoidal shapes, with rough crystalline surfaces. Colour, pale yellowish-white. H = 3·5, S.G = 2·75, which is a little below the actual, from the impossibility of clearing the crystals of the nearly white monite and gypsite, by which they are coated.

Primary form, right oblique angled prisms **M** on **T** about 143°. Secondary forms, terminal and acute lateral edges, replaced by single planes, the former generally very narrow. The surfaces of the crystals are without striæ or curvatures. The cleavage indeterminate. Fracture, uneven. Lustre, vitreous. Semi-transparent.

In a glass tube before the blowpipe turns white, and evolves a mixture. In the platinum forceps turns white, and melts into a globule with crystalline facets.

Composition :—

	I.	II.	mean.
Lime	39·92	40·59	40·255
Phosphoric acid	44·41	49·79	47·100
Sulphuric acid	7·20	1·90	4·550
Water	8·47	7·88	8·175
	100·00	100·16	100·088

2.—*Monite.*—Found intimately associated with monetite, is a hydrated tricalcic phosphate, resembling in colour and density the more friable varieties of kaolinite.

Characters: massive, slightly coherent, impalpable, and wholly uncrystalline; colour: snow-white, fracture earthy, dull; hardness below 2, S.G = 2·1 (approximately). B.B. melts with difficulty to an opaque, white enamel of feeble lustre. In closed tube emits much moisture.

Analyses :—

				mean.
P_2O_5	40·39	39·44	39·75	39·86
CaO	50·04	50·89	49·51	50·15
SO_3	—	2·57	1·75	2·16
H_2O	—	—	7·56	7·56
				99·73
Deducting 2·16 SO_3 = 1·51 CaO = 0·97 H_2O = gypsite ..				4·64
				95·09

The monetite is the most abundant species, occupying areas several inches long. The interspaces between the crystals occupy as much room as the crystals themselves; and are more or less filled up with the monite.

The associated gypsite is white, in small shining crystals, coarse fibrous individuals, small globules, fine granular and pulverulent.

The presence of silica, or some insoluble silicates, is detected in the analyses of the aggregates only, where it varies from 0·5 to 2· per cent.

Note on Crystals of Monetite.—The crystals of monetite placed in my hands may, with tolerable certainty, be referred to the triclinic system. The general form is that of a rather thin rhomboid. The longer lateral edge is replaced by the plane 100 (*a*), and the shorter by the hemi-prism, $\bar{1}10$ (I); there are also present in this zone the brachy pinacoid 010 (*b*), and two other hemi-prisms $h\bar{k}o$ (m and n) between 100 and $1\bar{1}0$, and a third hko (*l*), on the other side of 100. The top of the tabular crystals is formed by the basal plane 001 (*c*) which is rough and uneven, and the edge behind, between *a* and *c*, is replaced by a dome $\bar{1}01$ (*e*). The angles measured with the reflecting goniometer are only roughly approximate, and would not justify an attempt to calculate the axial ratios and inclinations. The supplement angles are: a I $(100\text{-}1\bar{1}0)=42°$, *ab* $(100\ 010)=81°$, $am=17°$, $a\,n=21°$, $a\,l=18°$, $a\,c=76°$, $a\,e\ (100\ \bar{1}01)=138°$. There appears to be a distinct cleavage parallel to *a*. The crystals often interpenetrate each other, forming complex groups, but there is no uniform law of composition.—E. S. DANA.

T.J.G.

PHILADELPHITE—A NEW MINERAL.—(H. C. LEWIS, *Jahrb. f. Min.* 1881. 2 Ref. 339; *Journ. Chim. Soc.*, Feb. 1882).—Pearly lustre; brown or yellow colour; the thin lamellæ are flexible; monosymmetrical. Cleavage basal; also in two directions parallel and perpendicular to the plane of the optical axes. On heating increases in volume tenfold. Comp:—

SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	V_2O_3.	FeO.	MnO.
35·73	1·03	15·77	19·46	0·37	2·18	0·50
NiO,CaO.	CaO.	MgO.	CuO.	Na_2O.	Li_2O.	K_2O.
0·06	0·08	11·56	1·46	0·90	Trace	6·18
P_2O_5.	Cl.	H_2SO_4.	H_2O.			
0·11	Trace	Trace	4·34			

Formula $R^{II}_4\ R^{VI}_2\ Si_5\ O_{20}\ 2\ H_2O$.

T.J.G.

CYPRUSITE.—(P. F. REINSCH, *Proc. Roy. Soc.*, XXXIII., 119, 1881.)—A supposed new mineral, composed chiefly of ferric sulphate, from the island of Cyprus.

Colour, yellowish. H=2. G=1·7. Partially soluble in water, soluble in boiling H.Cl., leaving a siliceous residue. This mineral contains a large percentage of well-preserved shells of microscopic Radiolaria.

Approximate analysis :—

Ferric oxide with alumina	51·5
Sulphuric acid	21·5
Residue insoluble in HCl (silicate, &c.) ..	25·0
Water	2·

T.J.G.

COSSYRITE.—H. FORSTNER, *Jahrb. f. Min.*, 1881, 2 Ref. 332—334; *Chem. Soc. Journ.*, February, 1882.)—A new mineral from Lipartite Lavas, of the island Pantellaria. The crystals are generally twins, 1·5 m.m. long; colour black, with vitreous lustre on the prismatic faces, the others dull. Cleavage parallel to 2 prismatic faces, which make an angle of 114°9′. Crystalline system, symmetrical with the axial relations, a : b : c = 0·6469 : 1 : 0·6635.

Composition :—

SiO_2.	Fe_2O_3.	Al_2O_3.	FeO.	MnO.	CuO.	CaO.	MgO.	Na_2O.
43·55	7·97	4·96	32·87	1·98	0·39	2·01	0·86	5·29

K_2O 0·33 =100·21.

S.Gr. = 3·74—3·75. T.J.G.

ANALYSIS OF THORITE FROM HITTERÖ, (G. LINDSTRÖM, *Jahrb. f. Min.*, 1881, 1 Ref. 29; *Chem. Soc. Journ.*, March, 1882.

Silica	17·47	Manganous oxide	0·43
Phosphoric oxide ..	0·93	Alumina	0·12
Lead oxide	1·26	Lime	1·39
Thorium	48·66	Magnesia	0·05
Yttrium earth	1·58	Lime	0·18
Cerium	1·54	Soda	0·12
Ferric Oxide	6·59	Loss by ignition	10·88
Uranous oxide	9·00		100·20

This agrees with the analysis by Nordenskjöld of the thorite from Arendal.

BEEGERITE.—(KONIG, G. A., *Am. Chem. Journ.*, ii., 379, 1881).—A new mineral, found in small crystals associated with quartz, on the Baltic lode of the Geneva Mining Company, at Grant Port office, Park Co., Colorado.

The crystals are regular combinations of the cube and octohedron, elongated in the direction of an octohedral edge. Very distinct cleavage. S. Gr. = 7·273. Colour light to dark grey. Lustre brilliant metallic. Heated in a matrass, it decrepitates and melts at a read heat without subliming, in the open tube gives off sulphur dioxide, and at a strong heat traces of a white sublimate (antimony). On charcoal gives the reactions for lead and bismuth. The residue gives, with borax, a slight copper reaction. Dissolves in warm HCl.

S.	Bi.	Pb.	Cu.	
14·97	20·59	64·23	1·70	= 101·49.

ANNERÖDITE.—W. C. BRÖGGER, *Geol. För. Förh.*, v., 345, 1881.)—A new mineral found in the pegmatite vein at Anneröd, near Moss, Norway, associated with monazite, apatite, beryl, topaz, magnetite, &c. Colour black, streak blackish-brown or greenish-grey, opaque, except in very thin splinters. Fracture sub-conchoidal, H = 6. S.Gr. = 5·7. Found crystallized in groups of parallel fibres or radiated. Fuses on the edge with difficulty to a black glass.

Niobic oxide	48·13	Ferrous oxide	3·38
Stannic oxide	0·16	Manganous oxide	0·20
Silica	2·51	Lime	3·35
Zirconia	1·97	Magnesia	0·15
Uranous oxide	16·28	Potash	0·16
Thorina	2·37	Soda	0·32
Cerium oxides	2·56	Alumina	0·28
Yttrium	7·10	Water	8·19
Lead oxide	2·40		99·51

Orthorhombic axes—$\dot{c} : \bar{b} : \breve{a} = 0{\cdot}36103 : 1 : 0{\cdot}40369$.

SCHNEEBERGITE, A NEW MINERAL.—(A. BREZINA, *Jahrb. f. Min.*, 1881. *Ref.* 321—332; *Journ. Chem. Soc.*, Feb. 1882.)—Occurring in gypsum and anhydrite; locality Schneeberg in Tyrol. Found crystallized in transparent honey-yellow octahedrons, imbedded, with glassy to adamantine lustre. H = 6·5; S. Gr. = 4·1. Decompose with great difficulty by fused sodium potassium carbonate, was found by qualitative analysis to consist essentially of antimony, lime and iron, with traces of copper, bismuth, zinc, magnesium, and sulphuric acid. The crystals when containing enclosures of magnetic iron exhibit in polarised light a black cross, which is sometimes surrounded by concentric rings.

Dioptase from Arizona. (*Am. Journ. Science, April*, 1882.)—Brilliant crystals of this mineral have been recently found lining cavities in what is called locally the "mahogany ore," a dark-brown compact mixture, consisting principally of limonite and oxide of copper in varying proportions, occurring at the Bon Ton group of mines, near the head of Chase Creek, about nine miles from Clifton Arizona.

Smaltite from Colorado, (By M. N. Iles. *Am. Journ. Science, May*, 1882.) A sample from the surface croppings, recently discovered near Gothie, Gunnison County, Colorado, yielded :—

CO	11·59
Fe	11·99
As	63·82
SiO_2	2·60
Pb	2·05
S	1·55
Bi	1·13
Cu	0.16
Ni	Trace
Ag	,,
	(94·89 ?)

A purer sample yielded 15 per cent. cobalt.

T.J.G.

On the Beryl from Craveggia, Piedmont, (By Prof. G. Spezia. *Atti della R Accademia delle Scienze di Torino*, Vol. xvii, 1882.) The beryls occur with tourmalines and manganese garnets in loose blocks of gneiss near Craveggia in the Val Vigezzo. Prof. Spezia gives an analysis of the mineral, which contains 11·49 per cent. of glucina. C. L. N. F.

Geological and Mineralogical Notes on the Gneiss of Beura, (By Prof. G. Spezia. *Atti della R. Accademia delle Scienze di Torino*, Vol. xvii, 1882.) The quarries near Beura in the Ossola Valley, which have been worked for many centuries, furnish slabs of gneiss for making balconies, steps, and pavements, and as they are situated the banks of the river Toce, the stone can be put upon barges at once and sent by water to Milan.

The Beura gneiss is so fissile, that slabs may easily be obtained 20ft. long by 5ft. or more wide. At the Durodossola Museum there is a slab 9ft. long by 10ins. wide, of a uniform thickness of only $\frac{1}{5}$ inch.

There are two principal varieties of the rock, one contains a considerable quantity of schorl, and may best be described as a tourmaliniferous gneiss; the other is dislinguished by the felspar appearing in the form of nodules when seen in a section at right angles to the plane of stratification. Prof. Spezia gives a long list of minerals which occur either in cavities or joints in the gneiss or disseminated through it, and he points out many interesting details concerning them. The memoir is a valuable contribution to the geology of the Ossala Valley, and affords ample proof that the author is a worthy successor of the late Prof. Gastaldi. C. L. N. F.